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CLERK US DISTRICT COURT
SOUTHERN DISTRICT OF CALIFORNIA
BY ______ DEPUTY

IN THE UNITED STATES DISTRICT COURT

FOR THE SOUTHERN DISTRICT OF CALIFORNIA

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| GEOFFREY L. MCCABE, an individual residing in California,<br><br>Plaintiff,<br><br>vs.<br><br>FLOYD ROSE GUITARS, a Washington corporation; FLOYD ROSE MARKETING, INC., a Washington corporation; FLOYD D. ROSE, an individual residing in Washington; DAVITT & HANSER MUSIC CO., a Kentucky corporation; PING WELL INDUSTRIAL CO., Ltd., a Taiwan corporation; and DOES 1 through 10, inclusive,<br><br>Defendants. | CASE NO. 10 CV 0581 W JMA<br><br>**COMPLAINT FOR (1) INFRINGEMENT OF U.S. PATENT NO. 5,965,831; (2) INFRINGEMENT OF U.S. PATENT NO. 7,470,841; (3) INFRINGEMENT OF U.S. PATENT NO. 6,175,066; (4) INFRINGEMENT OF U.S. PATENT NO. 6,891,094; (5) INFRINGEMENT OF U.S. PATENT NO. 5,986,191; (6) FALSE MARKING; (7) COMMON LAW UNFAIR COMPETITION; AND (8) STATUTORY UNFAIR COMPETITION**<br><br>**DEMAND FOR JURY TRIAL** |

VIA FAX

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Plaintiff Geoffrey L. McCabe ("McCabe") hereby complains of Floyd Rose Guitars; Floyd Rose Marketing, Inc.; Floyd D. Rose, an individual; Davitt & Hanser Music Co.; Ping Well Industrial Co., Ltd.; and DOES 1 through 10 (collectively "Defendants"), and alleges as follows:

**INTRODUCTION**

1. This action involves technology relating to tremolo devices for stringed musical instruments such as electric guitars. A tremolo device typically includes a lever arm or bar (commonly known as a "whammy bar") attached to a bridge and/or tailpiece of an electric guitar. In use, a guitarist moves the tremolo bar back and forth to activate the tremolo device in order to vary the tension and/or length of all strings temporarily, thereby changing the pitch of those strings to create a tremolo or vibrato effect.

2. McCabe is informed and believes, and thereon alleges, that Clarence Leonidas Fender, also known as Leo Fender, is generally credited with introducing the first fulcrum tremolo device, on the Stratocaster electric guitar (or "Strat") in 1954. A fulcrum tremolo is a unique species of tremolo in that the entire tremolo, including both the bridge and tailpiece portions, pivots about a fulcrum axis and is held in an initial tuned position by the balance between the tension of the strings pulling the tremolo in one direction on the one hand, and biasing or tensioning springs, which connect the fulcrum tremolo to the instrument body, pulling the tremolo in the opposite direction on the other hand. The fulcrum tremolo is unique compared to other tremolo designs because a change in the tension of any string disturbs the initial position of the tremolo and thereby alters the initial harmonic tuning of the instrument. Accordingly, for the fulcrum tremolo, adjusting the tuning pegs on the head of the guitar to reestablish the string back to the initial pitch also, simultaneously, reestablishes the initial harmonic tuning of the instrument. Leo Fender was awarded U.S. Patent No. 2,741,146, on April 10, 1956, for his fulcrum tremolo design. Leo Fender founded the famous Fender Electric Instrument Manufacturing Company, which is now known as Fender Musical Instruments Corporation ("Fender").

3. McCabe is informed and believes, and thereon alleges, that in the mid to late 1970s, Defendant Floyd D. Rose developed an improved fulcrum tremolo by adding, among other

things, clamping devices positioned at the nut of the instrument and the bridge portion of the tremolo in order to clamp the guitar strings at two points after the instrument is first tuned by the tuning pegs at the head of the guitar. The purpose of the clamping devices is to improve the stability of the tuned condition of the strings during and after movement of the tremolo bar, which was not achievable with older tremolo devices such as those found on the Fender Strat. A fine tuner arrangement is included on the fulcrum tremolo to permit further tuning of the strings within a limited range after the strings have been clamped. Once the string clamps were engaged, the only means for adjusting string tension were by each of the fine tuner knobs, one for each string, located on the tremolo itself. Accordingly, this means that upon performing a single adjustment by at least one of the fine tuner adjustment knobs the string is returned back to initial pitch and simultaneously reestablishes the initial harmonic tuning of the instrument.

4. For his improvement of fulcrum tremolos, Defendant Floyd D. Rose was awarded U.S. Patent No. 4,171,661 (the '661 patent), on October 23, 1979, and U.S. Patent No. 4,497,236 (the '236 patent), on February 5, 1985. McCabe is informed and believes, and thereon alleges, that in 1977, Floyd Rose began commercializing his improved fulcrum tremolo design, which is still in production today and marketed under the brand name "Original Floyd Rose Fulcrum Tremolo." With the likes of world-renowned rock guitarists such as Eddie Van Halen adopting and endorsing the Original Floyd Rose Fulcrum Tremolo in the late 1970s and early 1980s, Floyd Rose and his related business entities generated unprecedented sales of tremolos devices and garnered significant royalties and royalty rates (believed to be up to 50% if not more) under the '661 patent and '236 patent for licensed third-party fulcrum tremolos and guitars with fulcrum tremolos. The '661 patent and the '236 patent expired in 1997 and 2002, respectively.

5. Beginning in the late 1980s, Plaintiff Geoffrey L. McCabe invented certain improved designs of fulcrum tremolos including, among other things, a fulcrum tremolo with a macro-tuner. A macro-tuner is a full range tuner, which permits both harmonic tuning of the instrument and the complete pitch tuning of each guitar string without the need for a tuning peg at the head of the guitar. For his improved fulcrum tremolo designs, Geoffrey L. McCabe has been awarded seven U.S. Patents since October of 1990, five of which are asserted here.

## JURISDICTION AND VENUE

6. This action arises under the Patent Laws of the United States, Title 35 of the United States Code.

7. This Court has subject matter jurisdiction under 28 U.S.C. §§ 1331, 1338(a), and 1367.

8. Venue is proper in this Judicial District under 28 U.S.C. §§ 1391 and 1400(b).

## THE PARTIES

9. Plaintiff Geoffrey L. McCabe ("McCabe") is an individual residing in Los Angeles, California.

10. McCabe is informed and believes, and thereon alleges, that Defendant Floyd Rose Guitars ("FRG") is a corporation organized and existing under the laws of the State of Washington, having a principal place of business located at 6855 176th Avenue, NE, Redmond, Washington 98052.

11. McCabe is informed and believes, and thereon alleges, that Defendant Floyd Rose Marketing, Inc. ("FRM") is a corporation organized and existing under the laws of the State of Washington, having a principal place of business located at 3301 State Route 66, Neptune, New Jersey 07753-2705.

12. McCabe is informed and believes, and thereon alleges, that Defendant Floyd D. Rose, an individual, resides at 215-259th Place NE, Sammamish, Washington 98074, and has access to corporate assets outside of normal corporate convention, is named herein to pierce the corporate veil and who otherwise contributes to infringement while holding a position shielded by the corporate identity.

13. McCabe is informed and believes, and thereon alleges, that Defendant Davitt & Hanser Music Co. ("DHM") is a corporation organized and existing under the laws of the State of Kentucky, having a principal place of business located at 2395 Arbor Tech Drive, Hebron, Kentucky 41048.

14. McCabe is informed and believes, and thereon alleges, that Defendant Ping Well Industrial Co., Ltd. ("PWI") is a corporation organized and existing under the laws of Taiwan,

having a principal place of business located at No. 51, Sho Yi 5 Lane, Taichung, Taiwan.

15. McCabe is ignorant of the true names and capacities of the individuals and entity Defendants sued herein as DOES 1 through 10, inclusive, and therefore sued these Defendants by such fictitious names. McCabe will amend the complaint to assert their true names when they have been ascertained.

## GENERAL ALLEGATIONS

16. On October 12, 1999, the United States Patent & Trademark Office ("PTO") duly and lawfully issued U.S. Patent No. 5,965,831, entitled "Tuning Means for Stringed Musical Instrument" ("the '831 patent"). A copy of the '831 patent is attached hereto as Exhibit A. McCabe owns the entire rights, title, and interest to the '831 patent.

17. On November 16, 1999, the PTO duly and lawfully issued U.S. Patent No. 5,986,191, entitled "Tuning Means for Fulcrum Tremolo" ("the '191 patent"). McCabe owns the entire rights, title, and interest to the '191 patent, a copy of which is attached hereto as Exhibit B.

18. On January 16, 2001, the PTO duly and lawfully issued U.S. Patent No. 6,175,066, entitled "Tuning Means for Stringed Musical Instrument" ("the '066 patent"). McCabe owns the entire rights, title, and interest to the '066 patent, a copy of which is attached hereto as Exhibit C.

19. On May 10, 2005, the PTO duly and lawfully issued U.S. Patent No. 6,891,094, entitled "Tuning Means for Stringed Musical Instrument" ("the '094 patent"). McCabe owns the entire rights, title, and interest to the '094 patent, a copy of which is attached hereto as Exhibit D.

20. On December 30, 2008, the PTO duly and lawfully issued U.S. Patent No. 7,470,841, entitled "Tuning Apparatus for Stringed Instrument" ("the '841 patent"). McCabe owns the entire rights, title, and interest to the '841 patent, a copy of which is attached hereto as Exhibit E

21. McCabe is informed and believes, and thereon alleges, that Defendants' SpeedLoader Tremolo and SpeedLoader Fixed Bridge, and guitars equipped with the SpeedLoader Tremolo or SpeedLoader Fixed Bridge (collectively, "the accused products") satisfy, either literally or under the doctrine of equivalents, every element recited in one or more claims of the '831, '191, '066, '094, and '841 patents. Each Defendant's actions infringe one or

more claims of the '831, '191, '066, '094, and '841 patents, and that the infringement has been and continues to be willful.

22. McCabe is informed and believes, and thereon alleges, that Defendants' guitars equipped with a SpeedLoader Tremolo or SpeedLoader Fixed Bridge include at least two commercial lines of guitars marketed under the brand names "Redmond Series" (versions 1-5 and K) and "Discovery Series." The Redmond Series and the Discovery Series of guitars do not have traditional tuning pegs on the head and are therefore tuned by a plurality of macro-tuners positioned on a fulcrum tremolo.

23. McCabe is informed and believes, and thereon alleges, that FRG makes, uses, sells, imports, exports, and/or offers for sale the accused products, and has a financial interest in the manufacture, sale, importation, and/or exportation of the accused products.

24. McCabe is informed and believes, and thereon alleges, that FRM makes, uses, sells, imports, exports, and/or offers for sale the accused products, and has a financial interest in the manufacture, sale, importation, and/or exportation of the accused products.

25. McCabe is informed and believes, and thereon alleges, that Floyd D. Rose makes and uses the accused products, and has a financial interest in the manufacture, sale, importation, and/or exportation of the accused products.

26. McCabe is informed and believes, and thereon alleges, that DHM uses, sells, imports, exports, and/or offers for sale the accused products, and has a financial interest in the distribution of the accused products through commercial channels.

27. McCabe is informed and believes, and thereon alleges, that PWI manufactures, sells, and imports, in whole or in part, into the United States for FRG, FRM, Floyd D. Rose, and/or DHM the accused products and/or components thereof.

28. McCabe is informed and believes, and thereon alleges, that Joseph F. Littenberg and John R. Nelson, attorneys for FRG, FRM, and/or Floyd D. Rose and possibly other attorneys at the law firm of Lerner, David, Littenberg, Krumholz & Mentlik LLP, own a major portion of and/or have a controlling interest in FRG and/or FRM.

29. McCabe is informed and believes, and thereon alleges, that on or about January

19, 2001, McCabe was introduced to and met with Defendant Floyd D. Rose at the request of Floyd D. Rose while attending the North American Music Merchants (NAMM) exhibition in Anaheim, CA. During that meeting, Floyd D. Rose requested to see and read the '831 patent in the presence of McCabe and Paul Reed Smith, a luthier, a named inventor on a number of U.S. patents, and the founder and owner of PRS Guitars. At that time, McCabe informed Floyd D. Rose of the October 31, 1990, priority date of the '831 patent. The meeting occurred at the exhibition booth of Schaller Electronic GmbH, a German manufacturer of components for musical instruments.

30. McCabe is informed and believes, and thereon alleges, that FRG, FRM, and/or Floyd D. Rose commercially introduced the accused products at the 2003 NAMM trade show in Anaheim, CA. McCabe witnessed one or more of the accused products placed on various manufacturers' guitars at that trade show including Fender, the largest manufacturer of musical products in the United States.

31. McCabe is informed and believes, and thereon alleges, that Floyd D. Rose understands and believes that the accused products infringe one or more claims of the '831, '191, '066, '094, and '841 patents, and hence wishes to take a license from or reach a reasonable and fair settlement with McCabe. Nonetheless, Joseph F. Littenberg and John R. Nelson, and possibly other attorneys at the law firm of Lerner, David, Littenberg, Krumholz & Mentlik LLP, who own a major portion of and/or have a controlling interest in FRG and/or FRM have at one time or another unreasonably and in bad faith thwarted any and all licensing or settlement negotiations between McCabe and FRG, FRM, and/or Floyd D. Rose.

32. McCabe is informed and believes, and thereon alleges, that previous counsel of McCabe, ISR Law, discussed the accused products vis-à-vis the claims of the '831, '191, and '066 patents with John Nelson, counsel for FRG, FRM, and/or Floyd D. Rose, at the January 2004 NAMM show in Anaheim, CA. McCabe's counsel followed up with an email to John Nelson regarding FRG's and FRM's infringement of the '831, '191, and '066 patents. Attorneys from ISR Law, who were working on McCabe's behalf at the time, included Michael G. Smith, a former patent examiner and registered patent attorney, and Ellis B. Rameriz, a former supervisory

patent examiner and registered patent attorney.

33. McCabe is informed and believes, and thereon alleges, that in May of 2005, after ISR Law dissolved and ended its relationship with McCabe, McCabe attempted to contact John Nelson regarding Defendants' infringement of the '831, '191, '066, and '094 patents. John Nelson directed McCabe to speak directly with Floyd D. Rose.

34. McCabe is informed and believes, and thereon alleges, that in January of 2006, while at the NAMM show in Anaheim, CA, McCabe approached Defendant Floyd D. Rose to discuss Defendants' infringement of the '831, '191, '066, and '094 patents. Defendant Floyd D. Rose directed McCabe to speak with John Nelson, who subsequently refused to speak with McCabe and directed McCabe to speak to Floyd D. Rose.

35. On November 3, 2006, the U.S. International Trade Commission ("ITC") instituted an investigation based on a complaint filed October 3, 2006, and supplemented October 24, 2006, by McCabe. *See In re Certain Stringed Musical Instruments and Components Thereof*, Inv. No. 337-TA-586, 71 Fed. Reg. 64738 (Nov. 3, 2006). The complaint alleged violations of section 337 of the Tariff Act of 1930, as amended, 19 U.S.C. § 1337, in the importation into the United States, the sale for importation, and the sale within the United States after importation of certain stringed musical instruments and components thereof by reason of infringement of one or more of claims 1-6, 8, 9, and 11 of the '066 patent; claims 1-6 of the '831 patent; claims 1 and 14-22 of the '094 patent; and claims 1-3, 6-10, 14, 15, 23, 27, 28, and 32 of the '191 patent. The complaint named as respondents FRG; Ibanez, Inc. (Hoshino) US ("Hoshino"); Vigier, Inc. ("Vigier"); and Schaller Electronic GmbH. On May 7, 2007, Hoshino and Vigier were terminated from the investigation on the basis of settlement agreements reached with McCabe.

36. On August 13, 2007, an evidentiary hearing in Inv. No. 337-TA-586 was conducted at the ITC in Washington, DC before the Honorable Charles E. Bullock, administrative law judge of the ITC. Counsel for McCabe appeared on behalf of McCabe, who testified at the hearing. None of the respondents made an appearance. Floyd D. Rose and his counsel did not attend the hearing. Rett Snotherly and T. Spence Chubb, attorneys with the ITC's Office of Unfair Import Investigations ("OUII"), appeared at the hearing on behalf of the ITC staff.

37. McCabe is informed and believes, and thereon alleges, that the OUII concluded during its independent fact investigation in ITC Inv. No. 337-TA-586 that one more of claims 1-6, 8, 9, and 11 of the '066 patent; claims 1-6 of the '831 patent; claims 1 and 14-22 of the '094 patent; and claims 1-3, 6-10, 14, 15, 23, 27, 28, and 32 of the '191 patent, were valid and enforceable, and infringed by FRG.

38. On December 3, 2007, Judge Bullock issued a final initial determination finding no violation of section 337 of the Tariff Act in ITC Inv. No. 337-TA-586 on the ground that complainant McCabe's activities did not satisfy the economic prong of the domestic industry requirement. Judge Bullock did not reach the questions of infringement, validity, and enforceability of the '066, '831, '094, and '191 patents. ITC Inv. No. 337-TA-586 was terminated by way of the Commission's Opinion on May 16, 2008.

39. On January 12, 2009, McCabe filed a complaint for patent infringement against FRM and Hipshot Products, Inc. ("Hipshot") in the United States District Court for the Central District of California (*Geoffrey McCabe v. Floyd Rose Marketing, Inc.*, Case No. 2:09-cv-00253-RGK-E). In the complaint, McCabe accused FRM of infringing one or more claims of the '831, '066, and '094 patents.

40. On March 2, 2009, McCabe submitted a first amended complaint for patent infringement in Case No. 2:09-cv-00253-RGK-E. In the first amended complaint, McCabe accused FRM of infringing one or more claims of the '831, '066, '094, and '841 patents.

41. On June 6, 2009, FRM was dismissed without prejudice from Case No. 2:09-cv-00253-RGK-E pursuant to Fed. R. Civ. Pro. No. 41(a) in order for McCabe to efficiently pursue his claims against Hipshot. At that time, McCabe was proceeding in the case pro se and planned to file a subsequent and separate lawsuit against FRM.

42. On October 4, 2009, Hipshot Products, Inc. was dismissed from Case No. 2:09-cv-00253-RGK-E upon Hipshot entering into a settlement agreement with McCabe for infringement of the '094, '066, and '841 patents. The settlement included compensation for past infringement of the '094, '066, and '841 patents, as well as a license under the '841 patent. Case No. 2:09-cv-00253-RGK-E was closed on February 11, 2010.

43. McCabe licenses all of his active U.S. patents including the '831, '191, '066, '094, and '841 patents. McCabe is informed and believes, and thereon alleges that licensees of those patents sell and distribute products worldwide through online stores, retail distribution efforts, direct sales force, and third-party wholesalers, resellers, and value added resellers.

44. McCabe is informed and believes, and thereon alleges, that approximately 6,000 Floyd Rose guitars incorporating a SpeedLoader Tremolo or SpeedLoader Fixed Bridge have entered the commercial market since introduction in 2003. Defendants also make, use, sell, offer for sale, import and/or export an unknown, but significant number of SpeedLoader Tremolo and SpeedLoader Fixed Bridge devices apart from the aforesaid Floyd Rose guitars.

45. McCabe is informed and believes, and thereon alleges, that FRG, FRM, Floyd D. Rose, and/or DHM make, sell, import, export, use and/or offer for sale replacement guitar strings under the brand name Floyd Rose SpeedLoader Guitar Strings for guitars equipped with the SpeedLoader Tremolo or SpeedLoader Fixed Bridge. The basis for the demand for the aforesaid replacement guitar strings is primarily the SpeedLoader Tremolo or SpeedLoader Fixed Bridge integrated in a guitar. There is no market for the aforesaid replacement guitar strings separate from guitars equipped with the SpeedLoader Tremolo or SpeedLoader Fixed Bridge.

46. McCabe is informed and believes, and thereon alleges, that Defendants have marked and continue to mark commercially available fulcrum tremolo devices with expired patent numbers including U.S. Patent No. 4,171,661 and U.S. Patent No. 4,497,236.

47. McCabe has requested the ITC to institute another investigation based on a complaint submitted on February 26, 2010, by McCabe. The complaint alleged violations of section 337 of the Tariff Act of 1930, as amended, 19 U.S.C. § 1337, in the importation into the United States, the sale for importation, and the sale within the United States after importation of certain stringed musical instruments and components thereof by reason of infringement of one or more of claims 1-6, 8, 9, and 11 of the '066 patent; claims 1-3, 5 and 6 of the '831 patent; claims 1, 14-18, and 20-22 of the '094 patent; claims 1-3, 6, 14, 23, 27, and 32 of the '191 patent; and claims 6, 8-11, 27, 29, and 31 of the '841 patent. The complaint names as respondents FRG; FRM; Floyd D. Rose; DHM; PW; Lerner, David, Littenberg, Krumholz & Mentlik, LLP; and

Hoshino.

**FIRST CLAIM FOR RELIEF**

**(Infringement of U.S. Patent No. 5,965,831)**

**(Against All Defendants)**

48. McCabe repeats, realleges, and incorporates by reference the allegations set forth in paragraphs 1 through 47 of this Complaint.

49. This is a claim for patent infringement and arises under the Patent Laws of the United States, Title 35 of the United States Code.

50. McCabe is informed and believes, and thereon alleges, that Defendants FRG, FRM, Floyd D. Rose, DHM, and PWI, through their agents, officers, directors, employees and servants, have been and are currently willfully and intentionally infringing the '831 patent by making, using, selling, importing, exporting, and/or offering to sell products such as, but not limited to the aforesaid accused products, that are covered by at least one claim of the '831 patent. Defendants' acts constitute infringement of the '831 patent in violation of 35 U.S.C. § 271.

51. McCabe is informed and believes, and thereon alleges, that Defendants' products such as, but not limited to the SpeedLoader Tremolo and the SpeedLoader Fixed Bridge, and guitars equipped with the SpeedLoader Tremolo or SpeedLoader Fixed Bridge satisfy, either literally or under the doctrine of equivalents, each and every element recited in one or more claims of the '831 patent.

52. McCabe is informed and believes, and thereon alleges, that Defendants' infringement will continue unless enjoined by this Court.

53. McCabe is informed and believes, and thereon alleges, that Defendants have derived and received, and will continue to derive and receive, gains, profits and advantages from the aforesaid acts of infringement in an amount that is not presently known to McCabe. By reason of the aforesaid acts of infringement, McCabe has been damaged and is entitled to monetary relief in an amount to be determined at trial.

54. Because of the aforesaid infringing acts, McCabe has suffered and continues to suffer great and irreparable injury, for which McCabe has no adequate remedy at law.

## SECOND CLAIM FOR RELIEF

**(Infringement of U.S. Patent No. 7,470,841)**

**(Against All Defendants)**

55. McCabe repeats, realleges, and incorporates by reference the allegations set forth in paragraphs 1 through 54 of this Complaint.

56. This is a claim for patent infringement and arises under the Patent Laws of the United States, Title 35 of the United States Code.

57. McCabe is informed and believes, and thereon alleges, that Defendants FRG, FRM, Floyd D. Rose, DHM, and PWI, through their agents, officers, directors, employees and servants, have been and are currently willfully and intentionally infringing the '841 patent by making, using, selling, importing, exporting, and/or offering to sell products such as, but not limited to the aforesaid accused products, that are covered by at least one claim of the '841 patent. Defendants' acts constitute infringement of the '841 patent in violation of 35 U.S.C. § 271.

58. McCabe is informed and believes, and thereon alleges, that Defendants' products such as, but not limited to the SpeedLoader Tremolo and the SpeedLoader Fixed Bridge, and guitars equipped with the SpeedLoader Tremolo or SpeedLoader Fixed Bridge satisfy, either literally or under the doctrine of equivalents, each and every element recited in one or more claims of the '841 patent.

59. McCabe is informed and believes, and thereon alleges, that Defendants' infringement will continue unless enjoined by this Court.

60. McCabe is informed and believes, and thereon alleges, that Defendants have derived and received, and will continue to derive and receive, gains, profits and advantages from the aforesaid acts of infringement in an amount that is not presently known to McCabe. By reason of the aforesaid acts of infringement, McCabe has been damaged and is entitled to monetary relief in an amount to be determined at trial.

61. Because of the aforesaid infringing acts, McCabe has suffered and continues to suffer great and irreparable injury, for which McCabe has no adequate remedy at law.

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**THIRD CLAIM FOR RELIEF**

**(Infringement of U.S. Patent No. 6,175,066)**

**(Against All Defendants)**

62. McCabe repeats, realleges, and incorporates by reference the allegations set forth in paragraphs 1 through 61 of this Complaint.

63. This is a claim for patent infringement and arises under the Patent Laws of the United States, Title 35 of the United States Code.

64. McCabe is informed and believes, and thereon alleges, that Defendants FRG, FRM, Floyd D. Rose, DHM, and PWI, through their agents, officers, directors, employees and servants, have been and are currently willfully and intentionally infringing the '066 patent by making, using, selling, importing, exporting, and/or offering to sell products such as, but not limited to the aforesaid accused products, that are covered by at least one claim of the '066 patent. Defendants' acts constitute infringement of the '066 patent in violation of 35 U.S.C. § 271.

65. McCabe is informed and believes, and thereon alleges, that Defendants' products such as, but not limited to the SpeedLoader Tremolo and the SpeedLoader Fixed Bridge, and guitars equipped with the SpeedLoader Tremolo or SpeedLoader Fixed Bridge satisfy, either literally or under the doctrine of equivalents, each and every element recited in one or more claims of the '066 patent.

66. McCabe is informed and believes, and thereon alleges, that Defendants' infringement will continue unless enjoined by this Court.

67. McCabe is informed and believes, and thereon alleges, that Defendants have derived and received, and will continue to derive and receive, gains, profits and advantages from the aforesaid acts of infringement in an amount that is not presently known to McCabe. By reason of the aforesaid acts of infringement, McCabe has been damaged and is entitled to monetary relief in an amount to be determined at trial.

68. Because of the aforesaid infringing acts, McCabe has suffered and continues to suffer great and irreparable injury, for which McCabe has no adequate remedy at law.

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**FOURTH CLAIM FOR RELIEF**

**(Infringement of U.S. Patent No. 6,891,094)**

**(Against All Defendants)**

69. McCabe repeats, realleges, and incorporates by reference the allegations set forth in paragraphs 1 through 68 of this Complaint.

70. This is a claim for patent infringement and arises under the Patent Laws of the United States, Title 35 of the United States Code.

71. McCabe is informed and believes, and thereon alleges that Defendants FRG, FRM, Floyd D. Rose, DHM, and PWI, through their agents, officers, directors, employees and servants, have been and are currently willfully and intentionally infringing the '094 patent by making, using, selling, importing, exporting, and/or offering to sell products such as, but not limited to the aforesaid accused products, that are covered by at least one claim of the '094 patent. Defendants' acts constitute infringement of the '094 patent in violation of 35 U.S.C. § 271.

72. McCabe is informed and believes, and thereon alleges, that Defendants' products such as, but not limited to the SpeedLoader Tremolo and the SpeedLoader Fixed Bridge, and guitars equipped with the SpeedLoader Tremolo or SpeedLoader Fixed Bridge satisfy, either literally or under the doctrine of equivalents, each and every element recited in one or more claims of the '094 patent.

73. McCabe is informed and believes, and thereon alleges, that Defendants' infringement will continue unless enjoined by this Court.

74. McCabe is informed and believes, and thereon alleges, that Defendants have derived and received, and will continue to derive and receive, gains, profits and advantages from the aforesaid acts of infringement in an amount that is not presently known to McCabe. By reason of the aforesaid acts of infringement, McCabe has been damaged and is entitled to monetary relief in an amount to be determined at trial.

75. Because of the aforesaid infringing acts, McCabe has suffered and continues to suffer great and irreparable injury, for which McCabe has no adequate remedy at law.

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**FIFTH CLAIM FOR RELIEF**

**(Infringement of U.S. Patent No. 5,986,191)**

**(Against All Defendants)**

76. McCabe repeats, realleges, and incorporates by reference the allegations set forth in paragraphs 1 through 75 of this Complaint.

77. This is a claim for patent infringement and arises under the Patent Laws of the United States, Title 35 of the United States Code.

78. McCabe is informed and believes, and thereon alleges that Defendants FRG, FRM, Floyd D. Rose, DHM, and PWI, through their agents, officers, directors, employees and servants, have been and are currently willfully and intentionally infringing the '191 patent by making, using, selling, importing, exporting, and/or offering to sell products such as, but not limited to the aforesaid accused products, that are covered by at least one claim of the '191 patent. Defendants' acts constitute infringement of the '191 patent in violation of 35 U.S.C. § 271.

79. McCabe is informed and believes, and thereon alleges, that Defendants' products such as, but not limited to the SpeedLoader Tremolo and the SpeedLoader Fixed Bridge, and guitars equipped with the SpeedLoader Tremolo or SpeedLoader Fixed Bridge satisfy, either literally or under the doctrine of equivalents, each and every element recited in one or more claims of the '191 patent.

80. McCabe is informed and believes, and thereon alleges, that Defendants' infringement will continue unless enjoined by this Court.

81. McCabe is informed and believes, and thereon alleges, that Defendants have derived and received, and will continue to derive and receive, gains, profits and advantages from the aforesaid acts of infringement in an amount that is not presently known to McCabe. By reason of the aforesaid acts of infringement, McCabe has been damaged and is entitled to monetary relief in an amount to be determined at trial.

82. Because of the aforesaid infringing acts, McCabe has suffered and continues to suffer great and irreparable injury, for which McCabe has no adequate remedy at law.

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**SIXTH CLAIM FOR RELIEF**

**(False Marking)**

**(Against Defendants FRG, FRM, and Floyd D. Rose)**

83. McCabe repeats, realleges, and incorporates by reference the allegations set forth in paragraphs 1 through 82 of this Complaint.

84. This claim is for false patent marking arising under the Patent Laws of the United States, Title 35.

85. McCabe is informed and believes, and thereon alleges, that FRG, FRM, and/or Floyd D. Rose violated and continue to violate 35 U.S.C. § 292, by marking and continuing to mark articles with expired patents, with an intent to deceive the public.

86. McCabe is informed and believes, and thereon alleges, that FRG, FRM, and/or Floyd D. Rose did not have a reasonable belief that the articles were properly marked.

87. McCabe is informed and believes, and thereon alleges, that FRG, FRM, and/or Floyd D. Rose market and sell tremolo devices including, but not limited to the Original Floyd Rose Fulcrum Tremolo, SpeedLoader Tremolo and SpeedLoader Fixed Bridge, as well as guitars equipped with the aforesaid tremolo devices marked with U.S. Patent No. 4,171,661, which expired on January 3, 1997.

88. McCabe is informed and believes, and thereon alleges, that FRG, FRM, and/or Floyd D. Rose market and sell tremolo devices including, but not limited to the Original Floyd Rose Fulcrum Tremolo, SpeedLoader Tremolo and SpeedLoader Fixed Bridge, as well as guitars equipped with the aforesaid tremolo devices marked with U.S. Patent No. 4,497,236, which expired on March 15, 2002.

89. McCabe is informed and believes, and thereon alleges, that during the January 2010 NAMM Show in Anaheim, CA, FRG, FRM, and/or Floyd D. Rose marketed and offered for sale tremolo devices including, but not limited to the Original Floyd Rose Fulcrum Tremolo, SpeedLoader Tremolo and SpeedLoader Fixed Bridge, as well as guitars equipped with the aforesaid tremolo devices marked with U.S. Patent No. 4,171,661 and U.S. Patent No. 4,497,236.

90. McCabe is informed and believes, and thereon alleges, that each aforesaid falsely

marked article is likely to, or at least has the potential to, discourage or deter persons and companies from commercializing competing products.

91. McCabe is informed and believes, and thereon alleges, that each aforesaid falsely marked article has wrongfully quelled competition with respect to such articles, thereby causing harm to McCabe, the United States, and the public at large.

92. McCabe is informed and believes, and thereon alleges, that FRG, FRM, and/or Floyd D. Rose have improperly procured eleven (11) patents issued in the mid to late 1990s, entitled "Tuning Systems for Stringed Musical Instruments," which claim various aspects of fulcrum tremolo and fixed-bridge devices capable of achieving convergent tuning ("the Floyd Rose convergent tuning patents"). "Convergent tuning" is a term that was introduced by Floyd D. Rose and/or his representatives around the filing of the Floyd Rose convergent tuning patents and refers to the substantially simultaneous occurrence of harmonic and pitch tuning of multiple strings of a guitar or other stringed instruments.

93. McCabe is informed and believes, and thereon alleges, that the subject matter of the Floyd Rose convergent tuning patents are claiming inventions originally disclosed, taught, and/or suggested in U.S. Patent No. 4,171,661 and/or U.S. Patent No. 4,497,236, and/or embodied by the Original Floyd Rose Fulcrum Tremolo. The Floyd Rose convergent tuning patents improperly extend the expired patent rights associated with U.S. Patent No. 4,171,661 and/or U.S. Patent No. 4,497,236.

94. McCabe is informed and believes, and thereon alleges, that FRG, FRM, and/or Floyd D. Rose have deceptively claimed at public meetings as well as in public literature that the SpeedLoader Tremolo is unique in that it practices convergent tuning. McCabe is informed and believes, and thereon alleges, the Original Floyd Rose Fulcrum Tremolo, which dates back to the 1970s, practices convergent tuning.

95. McCabe is informed and believes, and thereon alleges, that Defendants FRG, FRM, and/or Floyd D. Rose specifically sought, in the instance of the SpeedLoader Tremolo, to mislead the public away from the improperly procured Floyd Rose convergent tuning patents by marking commercially available SpeedLoader Tremolos with expired patent numbers, U.S. Patent

No. 4,171,661 and/or U.S. Patent No. 4,497,236.

96. McCabe is informed and believes, and thereon alleges, that several international distributors of licensed Floyd Rose tremolos are currently distributing Floyd Rose fulcrum tremolos marked with the expired patent numbers, U.S. Patent No. 4,171,661 and/or U.S. Patent No. 4,497,236. McCabe witnessed the aforesaid falsely marked tremolo devices while attending the January 2010 NAMM Show in Anaheim, CA.

97. McCabe is informed and believes, and thereon alleges, that FRG, FRM, and/or Floyd D. Rose wrongfully and illegally advertised and continue to advertise a patent monopoly in which they do not possess and, as a result, have benefited commercially and financially by maintaining false statements of patent rights.

**SEVENTH CLAIM FOR RELIEF**

**(Common Law Unfair Competition)**

**(Against FRG, FRM, and Floyd D. Rose)**

98. McCabe repeats, realleges, and incorporates by reference the allegations set forth in paragraphs 1 through 97 of this Complaint.

99. This claim is for unfair competition under California common law.

100. The acts of FRG, FRM, and Floyd D. Rose alleged herein include manufacturing, selling, and offering for sale articles marked with expired patent numbers and/or improperly obtained patent numbers for the purpose of increasing sales and profits constitute unlawful, unfair and fraudulent business practices in violation of California common law.

101. As a direct and proximate result of the aforesaid deceptive business practices, McCabe has and will continue to suffer great harm and damage. McCabe has incurred and will continue to incur irreparable harm unless Defendants are enjoined from further commission of unfair and unlawful business acts and practices against McCabe.

**EIGTH CLAIM FOR RELIEF**

**(Statutory Unfair Competition)**

**(Against FRG, FRM, and Floyd D. Rose)**

102. McCabe repeats, realleges, and incorporates by reference the allegations set forth

in paragraphs 1 through 101 of this Complaint.

103. This claim is for statutory unfair competition in violation of California Business & Professions Code § 17200 *et seq.*

104. The acts of FRG, FRM, and Floyd D. Rose alleged herein include manufacturing, selling, and offering for sale articles marked with expired patent numbers and/or improperly obtained patent numbers for the purpose of increasing sales and profits constitute unlawful, unfair and fraudulent business practices in violation of California Business & Professions Code § 17200 *et seq.*

105. As a direct and proximate result of the aforesaid deceptive business practices, McCabe has and will continue to suffer great harm and damage. McCabe has incurred and will continue to incur irreparable harm unless Defendants are enjoined from further commission of unfair and unlawful business acts and practices against McCabe.

**PRAYER FOR RELIEF**

WHEREFORE, McCabe prays for judgment in his favor against Defendants for the following relief:

A. An Order adjudging Defendants to have infringed the '831, '841, '066, '094 and '191 patents under 35 U.S.C. § 271;

B. An Order adjudging Defendants to have willfully infringed the '831, '841, '066, '094 and '191 patents under 35 U.S.C. § 271;

C. An injunction enjoining Defendants, their respective officers, directors, agents, servants, employees and attorneys, and those persons acting in concert or participation with Defendants, from directly or indirectly infringing the '831, '841, '066, '094 and '191 patents in violation of 35 U.S.C. § 271;

D. That Defendants account for all gains, profits, and advantages derived by Defendants' infringement of the '831, '841, '066, '094 and '191 patents in violation of 35 U.S.C. § 271, and that Defendants pay to McCabe all damages suffered by McCabe;

E. An order for a trebling of damages and/or exemplary damages because of Defendants' willful misconduct under 35 U.S.C. § 284;

F. An Order adjudging that this is an exceptional case;

G. An award to McCabe of the attorneys' fees and costs incurred by McCabe in connection with this action under 35 U.S.C. § 285;

H. An award of pre-judgment and post-judgment interest and costs of this action against Defendants;

I. That Defendants FRG, FRM, and Floyd D. Rose be adjudged to have falsely marked tremolo devices and guitars with an intent to deceive in violation of 35 U.S.C. § 292;

J. That Defendants FRG, FRM, and Floyd D. Rose be ordered to pay the maximum civil monetary fine of $500 for each and every falsely marked article;

K. That Defendants FRG, FRM, and Floyd D. Rose be adjudged to have competed unfairly and unlawfully with McCabe under California common law;

L. That Defendants FRG, FRM, and Floyd D. Rose be adjudged to have competed unfairly and unlawfully with McCabe under California Business & Professions Code §17200 *et seq.*;

M. That Defendants be directed to file with this Court and serve on Plaintiff within thirty (30) days after service of the injunction order, a report in writing signed under oath detailing the manner and form in which Defendants have complied with the injunction;

N. That Defendants be required to account to McCabe for any and all gains, profits and advantages derived or obtained by them, and all damages sustained by McCabe, by reason of Defendants' acts and conduct complained of herein, including Defendants' acts of patent infringement, false marking, and unfair competition;

O. That the Court deem this case an exceptional one under 15 U.S.C. § 1117 and award McCabe reasonable attorneys' fees; and

P. Such other and further relief as the Court may deem proper and just.

Dated: March 19, 2010

SAN DIEGO IP LAW GROUP LLP

By: ______________________
DOUGLAS E. OLSON
JAMES V. FAZIO, III
TREVOR Q. CODDINGTON
JESSICA S. MITCHELL

Attorneys for Plaintiff
GEOFFREY L. MCCABE

**DEMAND FOR JURY TRIAL**

McCabe hereby demands a trial by jury on all issues so triable.

Dated: March 19, 2010

SAN DIEGO IP LAW GROUP LLP

By: [signature]

DOUGLAS E. OLSON
JAMES V. FAZIO, III
TREVOR Q. CODDINGTON
JESSICA S. MITCHELL

Attorneys for Plaintiff
GEOFFREY L. MCCABE

EXHIBIT A

# EXHIBIT A

US005965831A

# United States Patent [19]

**McCabe**

[11] **Patent Number: 5,965,831**

[45] **Date of Patent: Oct. 12, 1999**

[54] **TUNING MEANS FOR STRINGED MUSICAL INSTRUMENT**

[76] Inventor: **Geoffrey L. McCabe**, 36 E. 7th St. 5W, New York, N.Y. 10003

[21] Appl. No.: **08/953,002**

[22] Filed: **Oct. 16, 1997**

**Related U.S. Application Data**

[60] Continuation of application No. 08/027,729, Jan. 14, 1993, which is a division of application No. 07/607,458, Oct. 31, 1990, Pat. No. 5,198,601.

[51] **Int. Cl.**[6] .......... **G10D 3/00**

[52] **U.S. Cl.** .......... **84/313**; 84/297 R; 84/303

[58] **Field of Search** .......... 84/313, 297 R, 84/298, 299, 307, 312 R

[56] **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 2,741,146 | 4/1956 | Fender . | |
| 3,457,821 | 7/1969 | McCarty . | |
| 4,171,661 | 10/1979 | Rose . | |
| 4,383,466 | 5/1983 | Shibuya . | |
| 4,457,201 | 7/1984 | Storey . | |
| 4,497,236 | 2/1985 | Rose . | |
| 4,512,232 | 4/1985 | Schaller . | |
| 4,724,737 | 2/1988 | Fender . | |
| 4,742,750 | 5/1988 | Storey . | |
| 4,768,415 | 9/1988 | Gressett, Jr. et al. | 84/313 |
| 4,955,275 | 9/1990 | Gunn . | |
| 5,419,227 | 5/1995 | Lavineway . | |
| 5,522,297 | 6/1996 | Enserink . | |

*Primary Examiner*—William M. Shoop, Jr.
*Assistant Examiner*—Kim Lockett
*Attorney, Agent, or Firm*—Dann, Dorfman, Herrell & Skillman, P.C.; Stephen H. Eland

[57] **ABSTRACT**

A stringed musical instrument is provided wherein each string has two critical points, A fulcrum tremolo is mounted on the instrument for varying the tension of the strings and the distance between the two critical points. The strings are attached to a plurality of intonation modules mounted on the fulcrum tremolo. Each intonation module is adjustable so that the strings can be adjusted from an untensioned state to a proper playing pitch. A bearing assembly is also included to facilitate pivoting of the fulcrum tremolo.

**12 Claims, 12 Drawing Sheets**

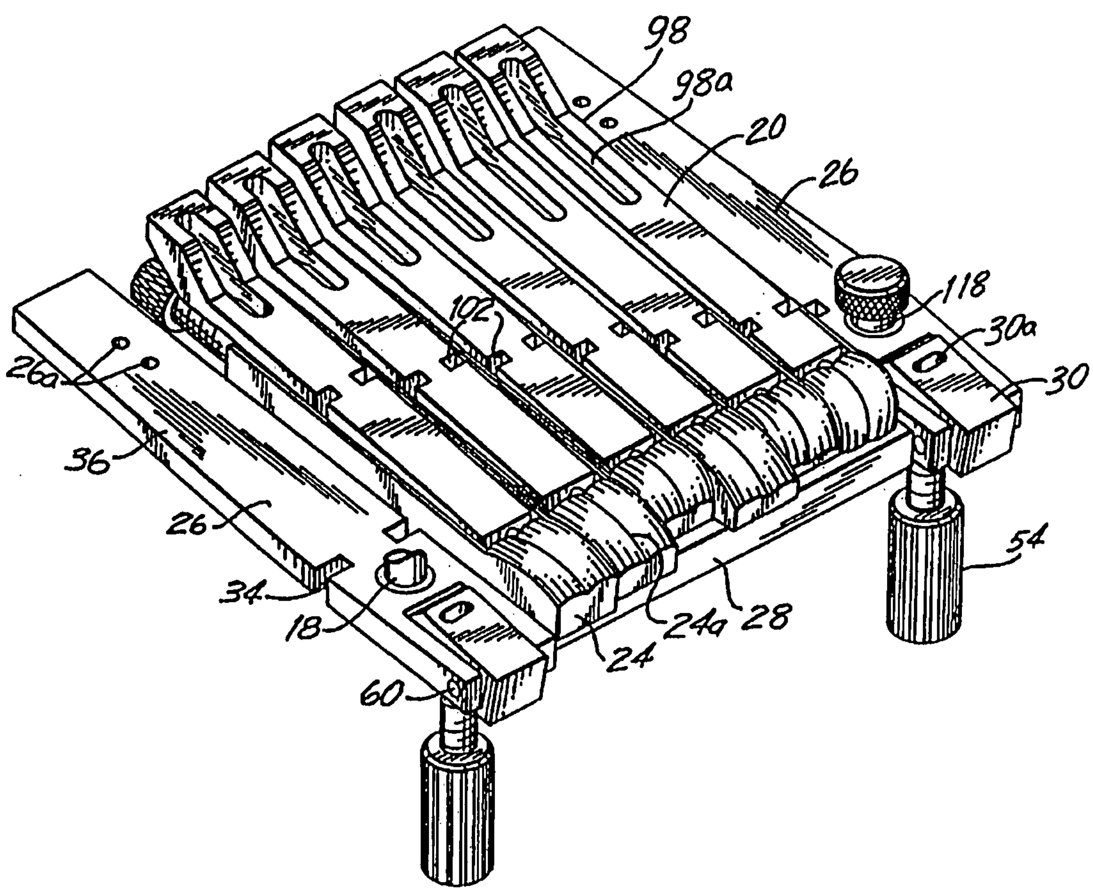
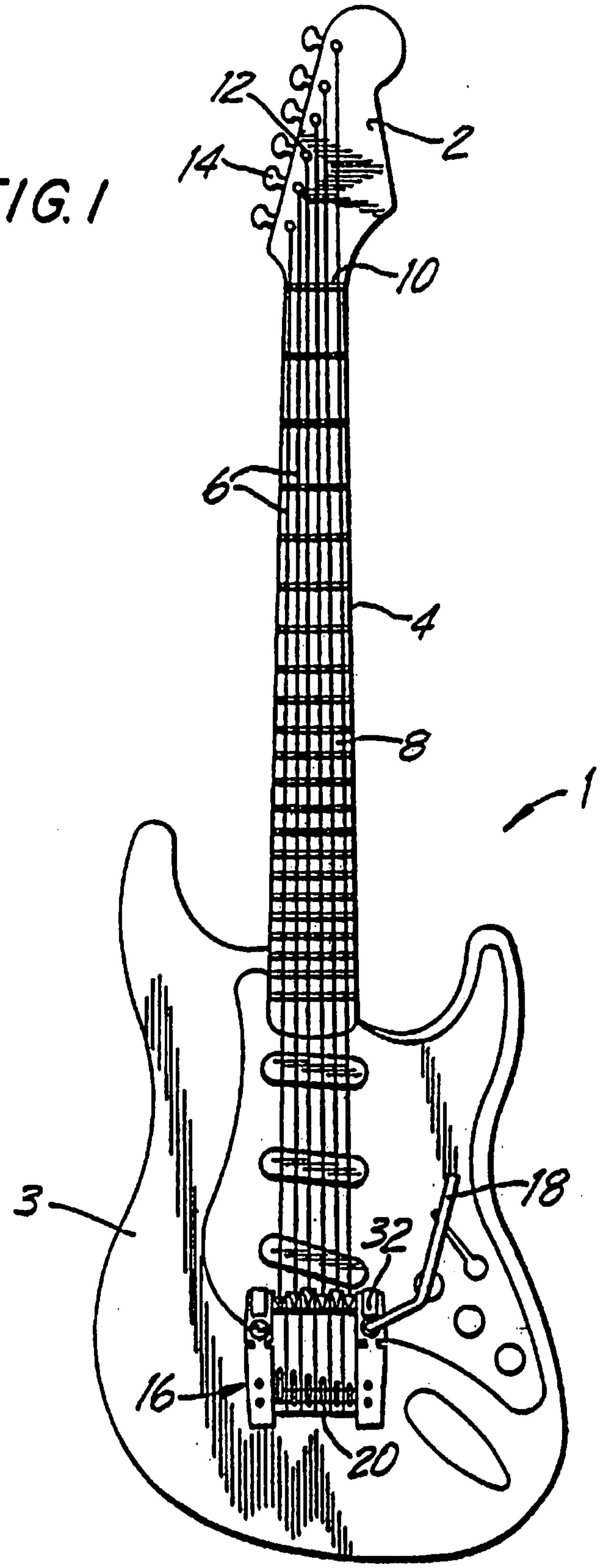


FIG. 1



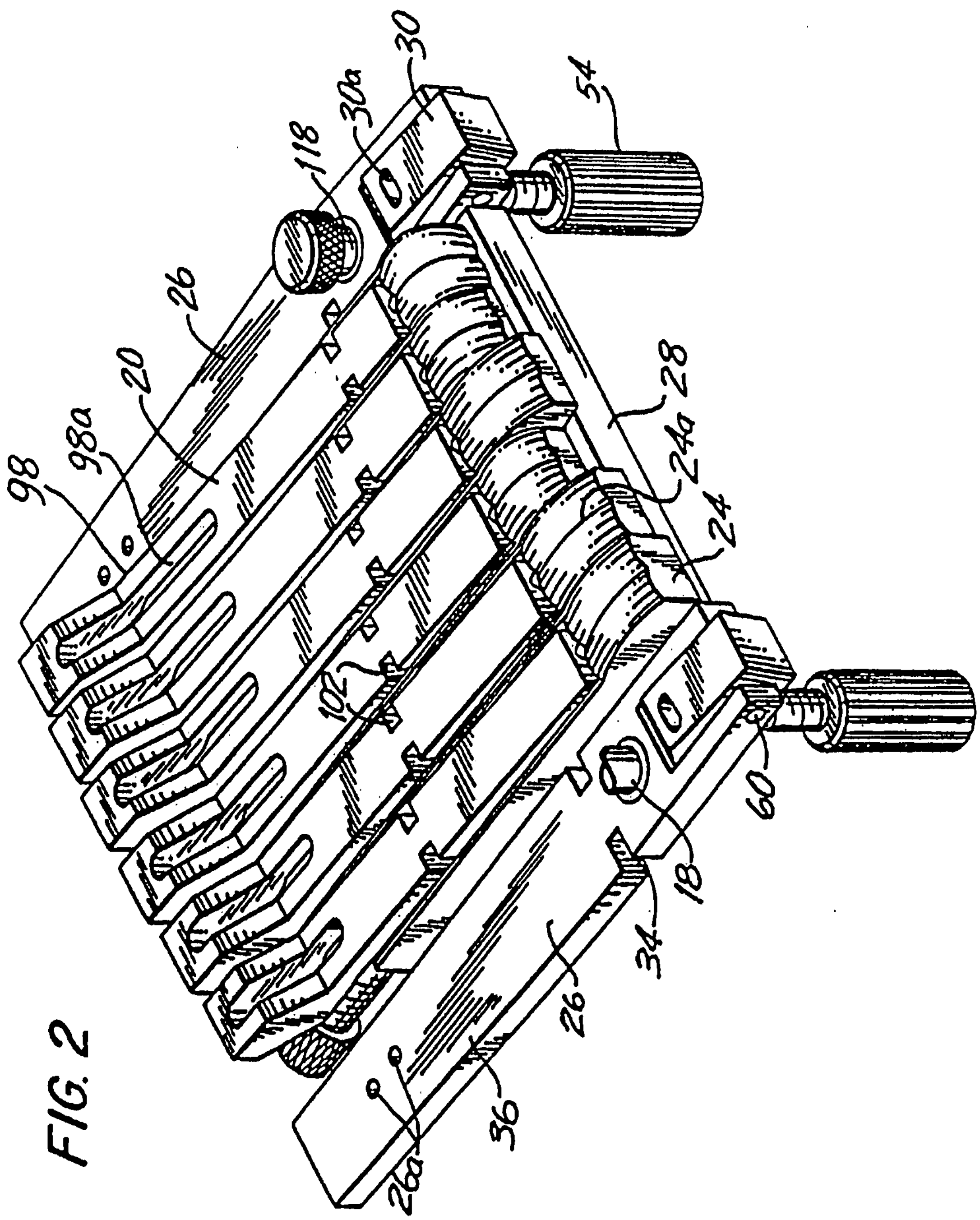
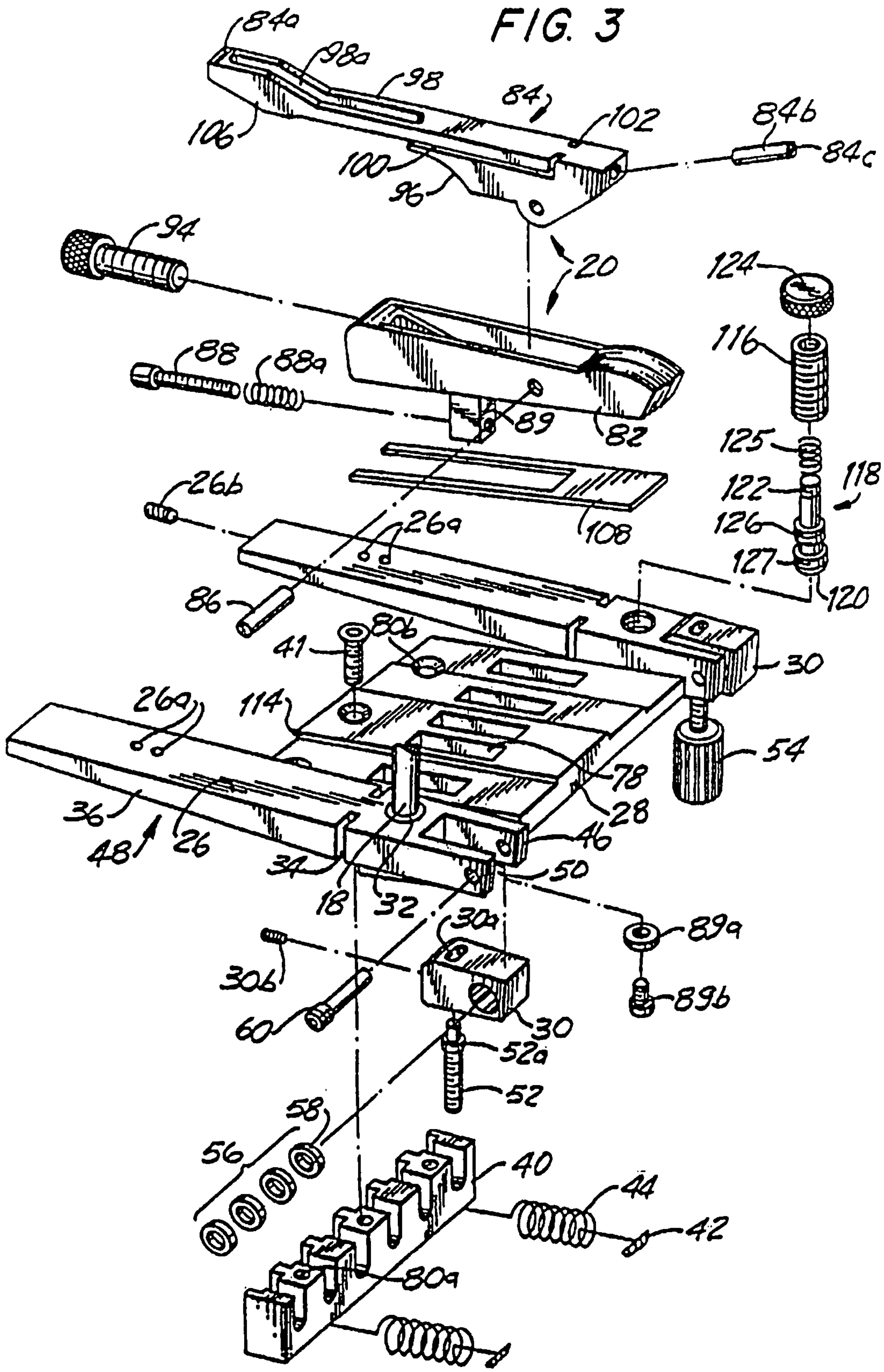



FIG. 2

FIG. 3


84a
98a
98
84
102
84b
84c
106
100
96
94
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116
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88a
89
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125
118
122
26b
108
126
26a
127
120
86
41
80b
30
26a
114
54
78
36
28
46
48
26
34
50
18
32
30a
89a
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89b
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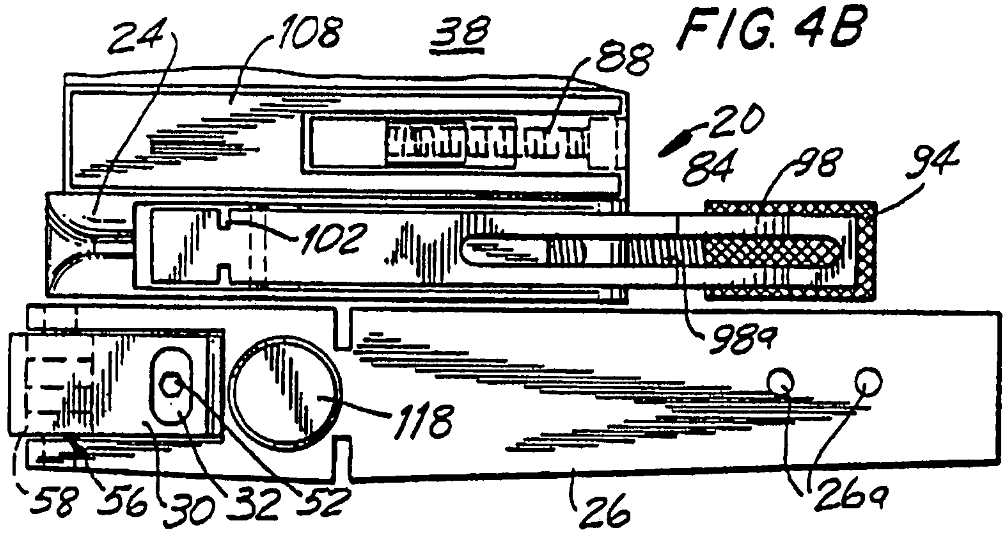
30
52a
52
58
56
40
44
42
80a

FIG. 4B



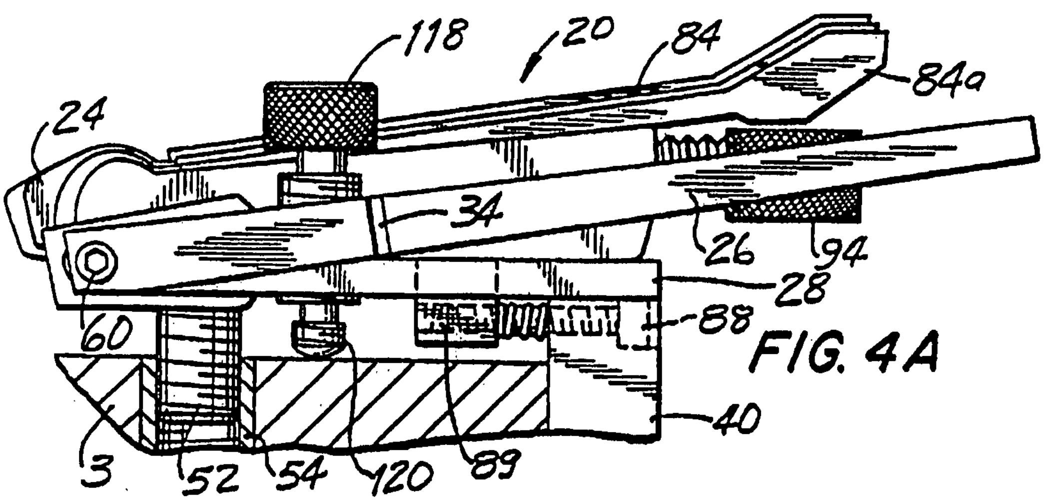




FIG. 4A

FIG. 4C

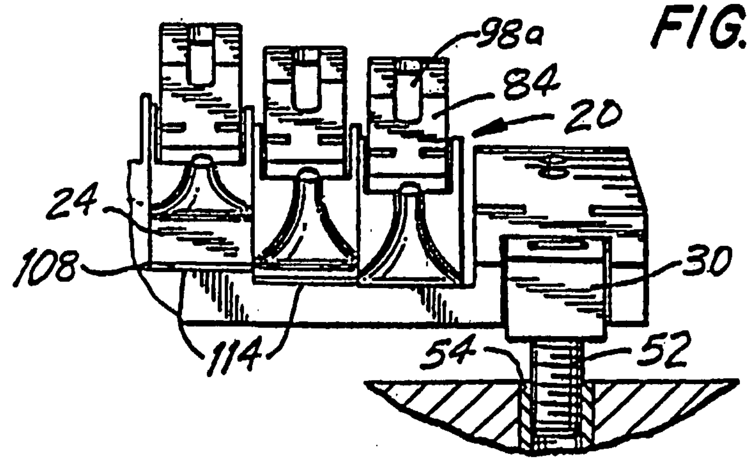


FIG. 5A

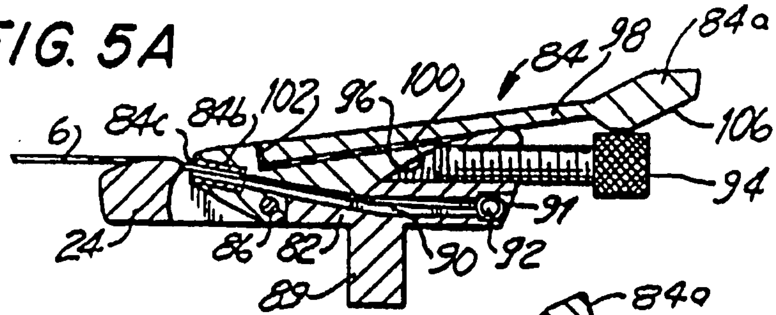



FIG. 5B

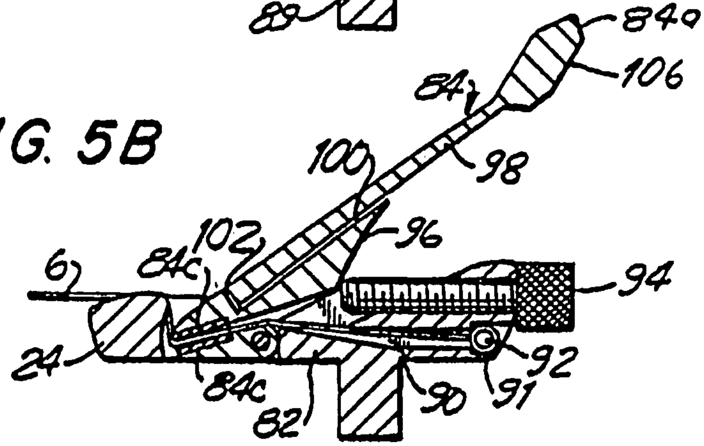



FIG. 7A

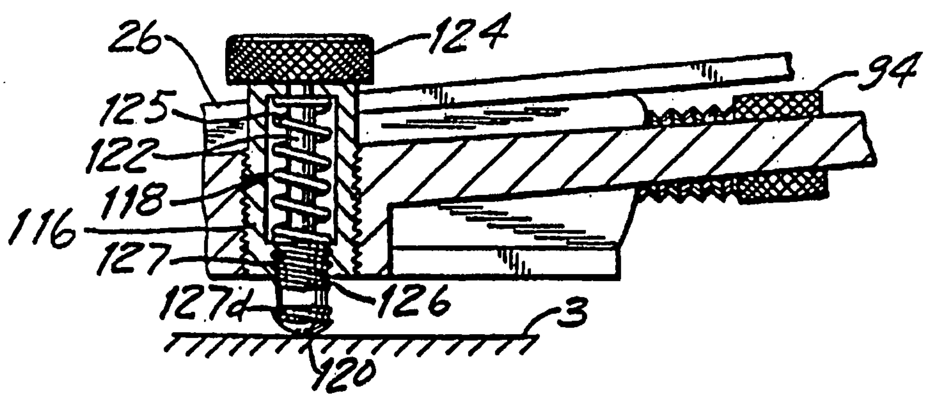



FIG. 7B

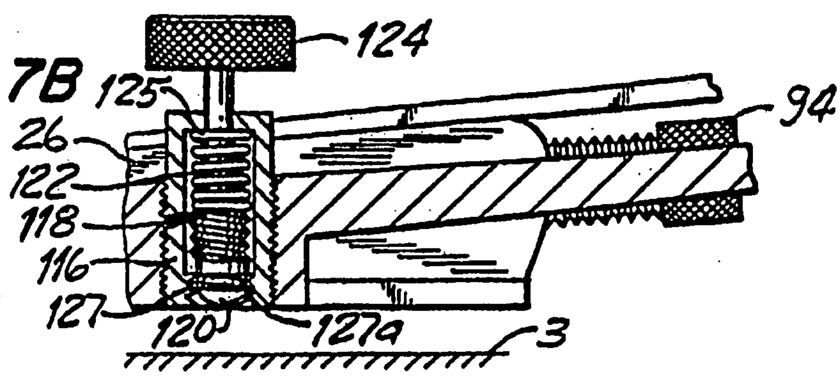


FIG. 6A

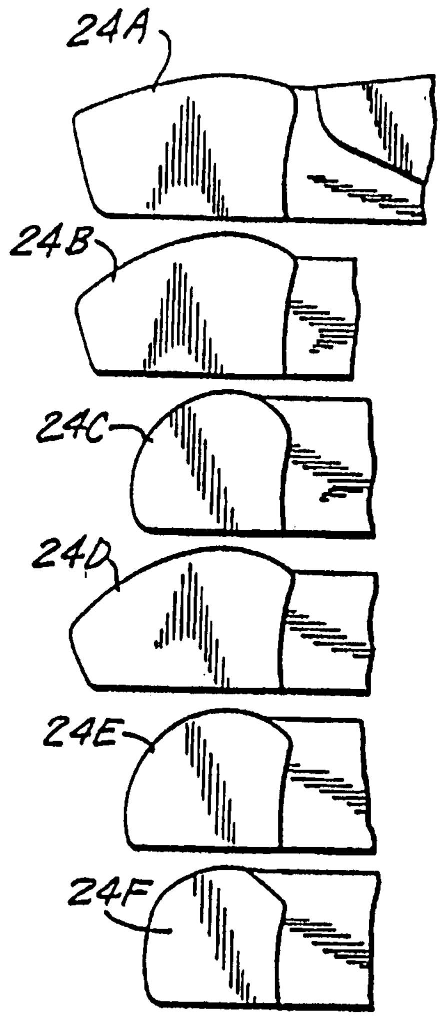
FIG. 6B

FIG. 6C

FIG. 6D

FIG. 6E

FIG. 6F



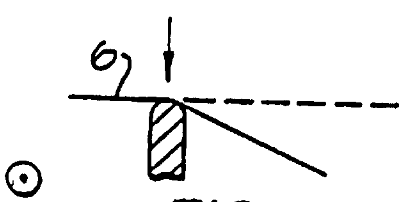




FIG. 6G
PRIOR ART

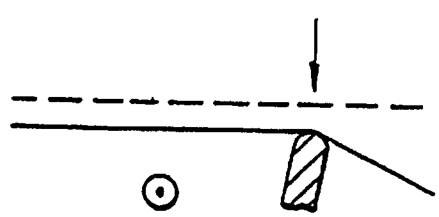


FIG. 6H
PRIOR ART

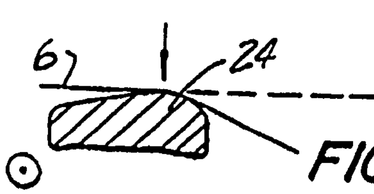



FIG. 6I

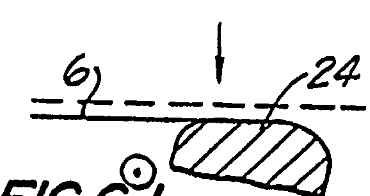



FIG. 6J

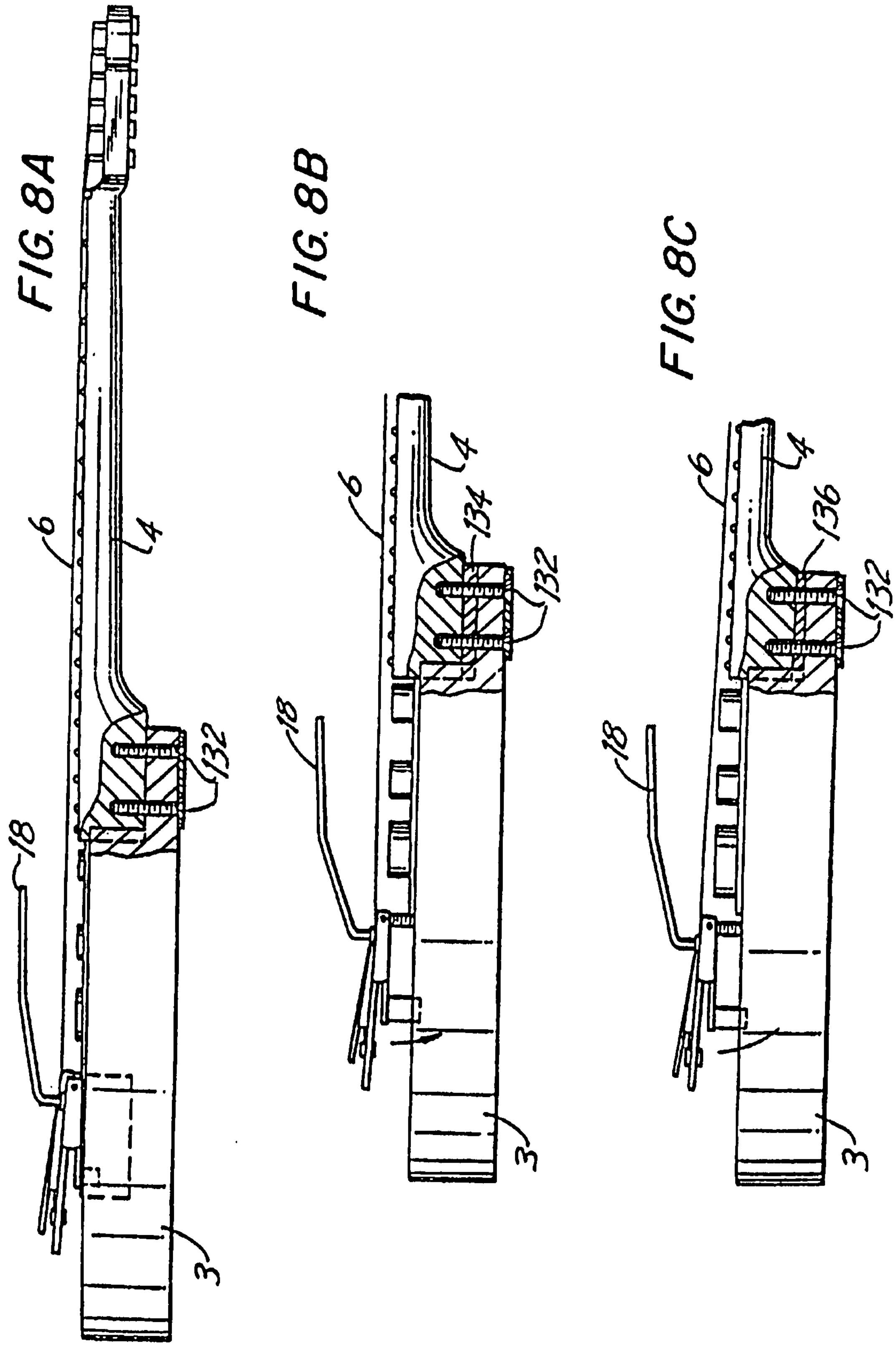



FIG. 8A

FIG. 8B

FIG. 8C

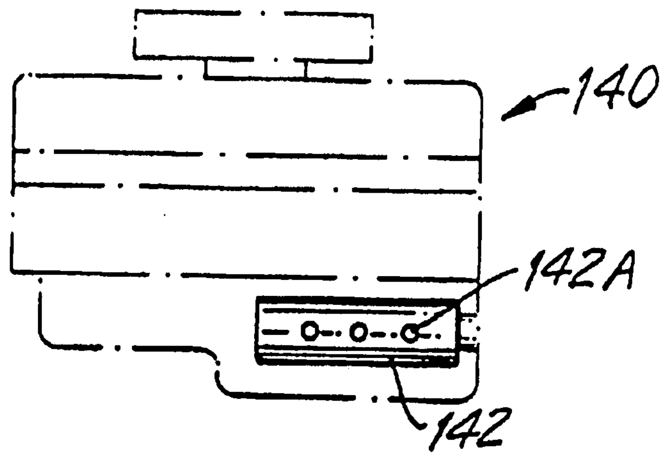
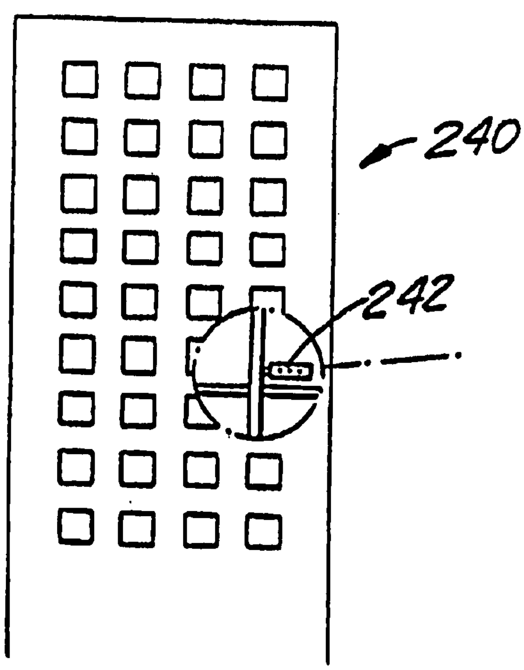



FIG. 9A



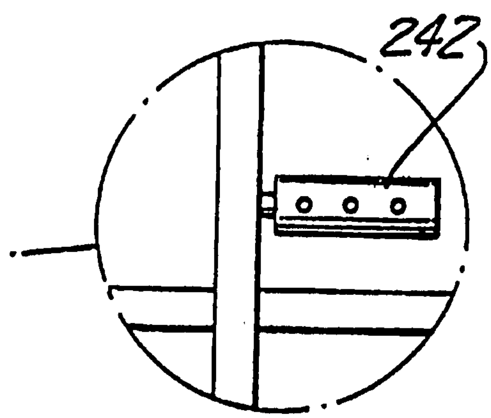




FIG. 9C

FIG. 9B

FIG. 10B-1

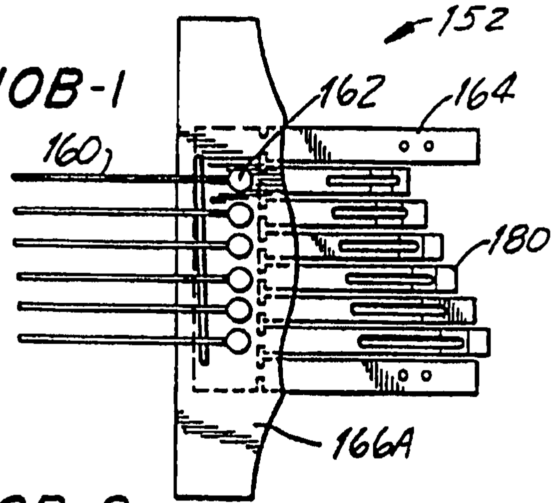



FIG. 10B-2

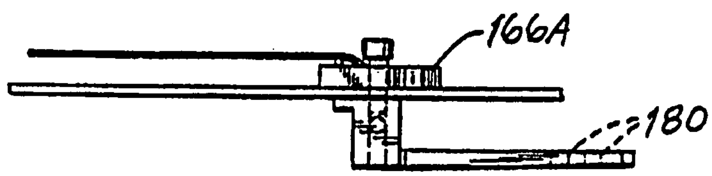



FIG. 10B-3

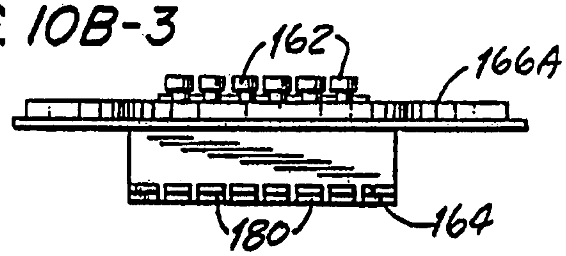
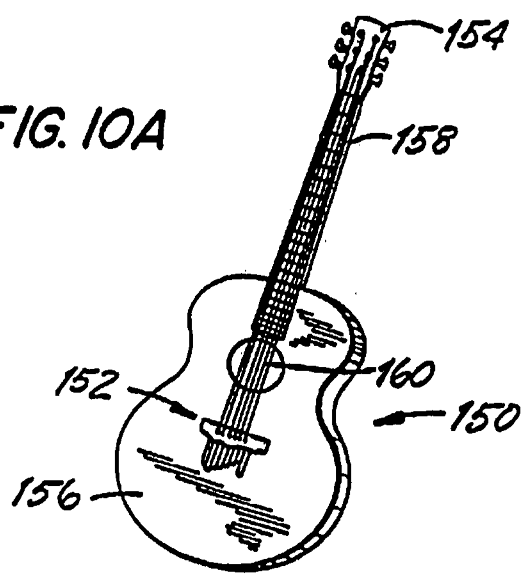



FIG. 10A



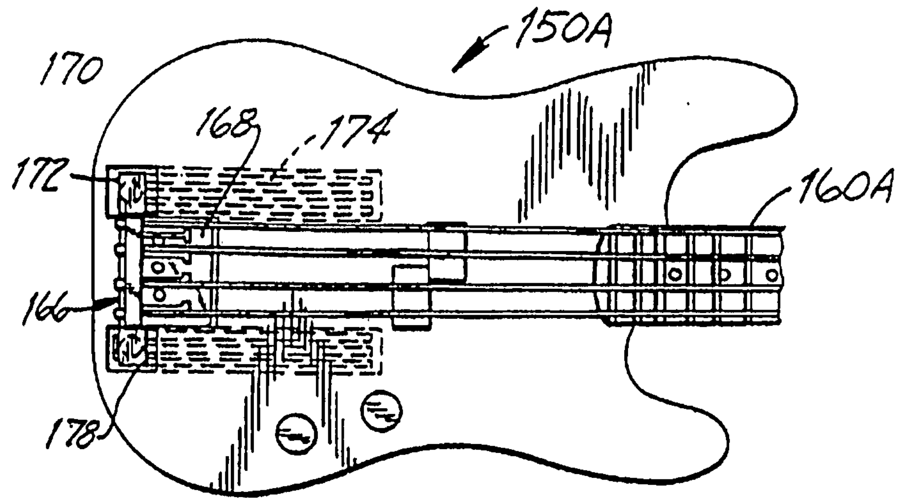



FIG. 10C-1

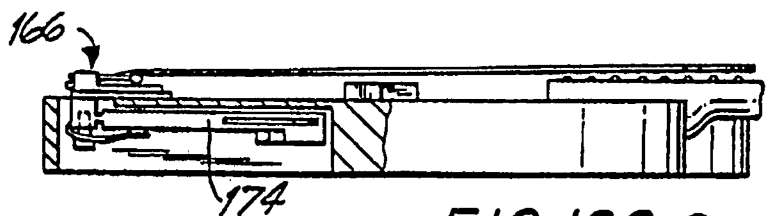



FIG. 10C-2

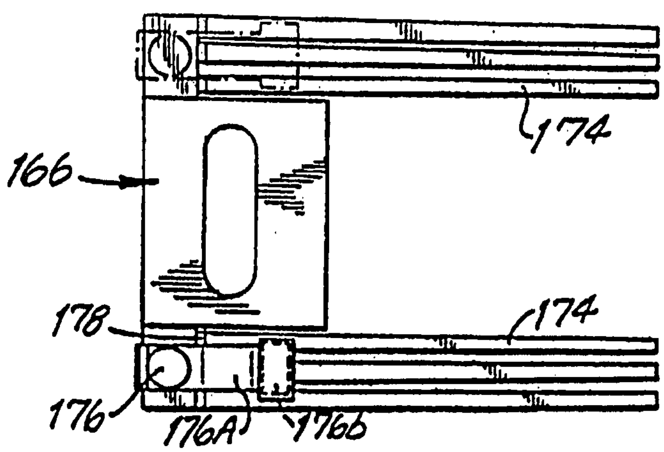



FIG. 10D-1

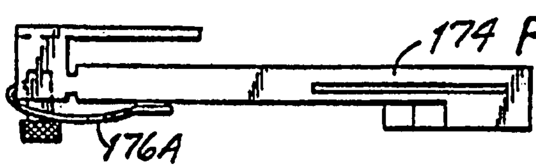



FIG. 10D-2

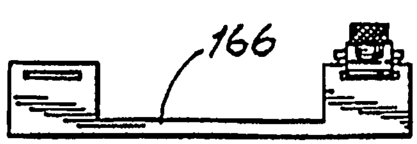



FIG. 10D-3

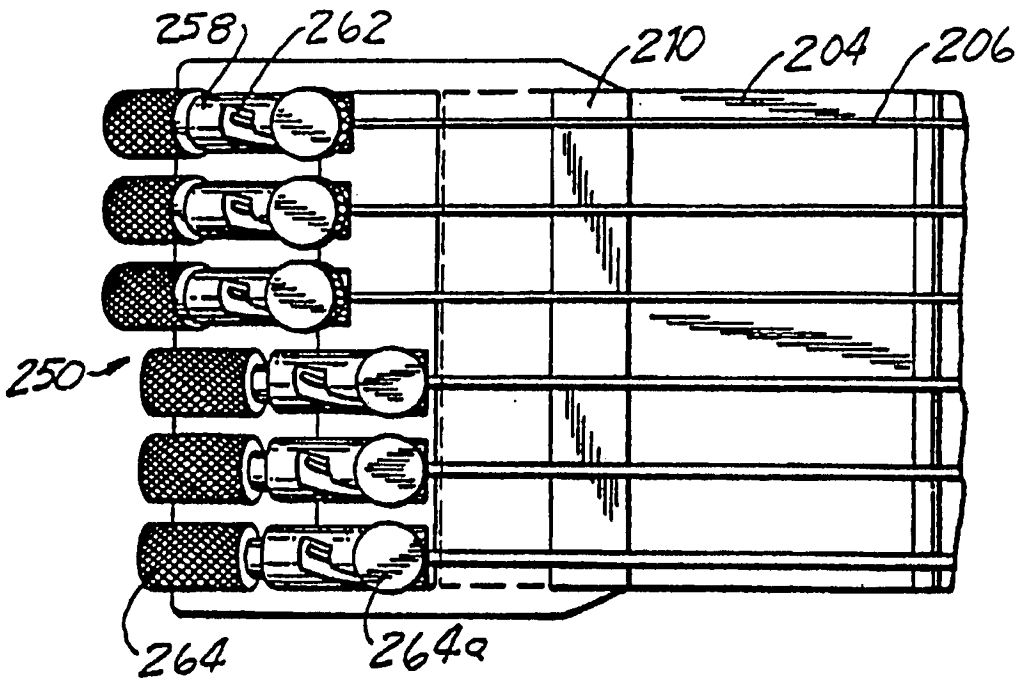



FIG. 11A

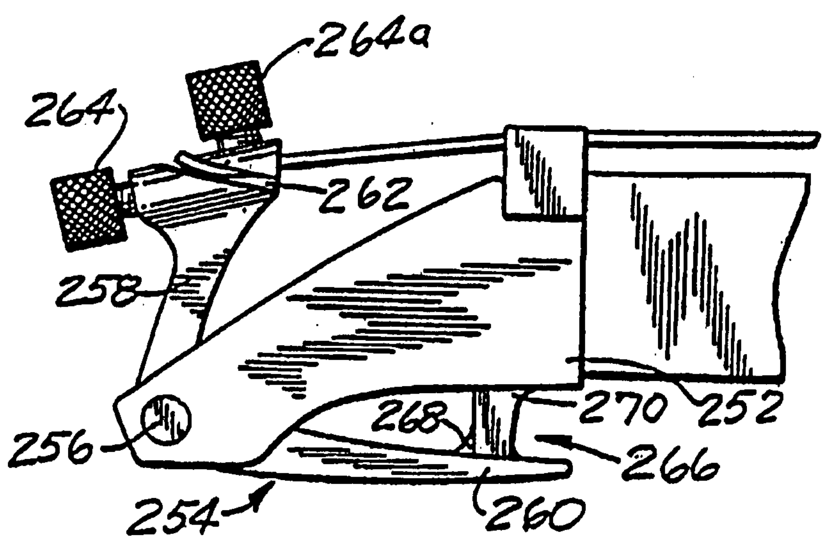



FIG. 11B

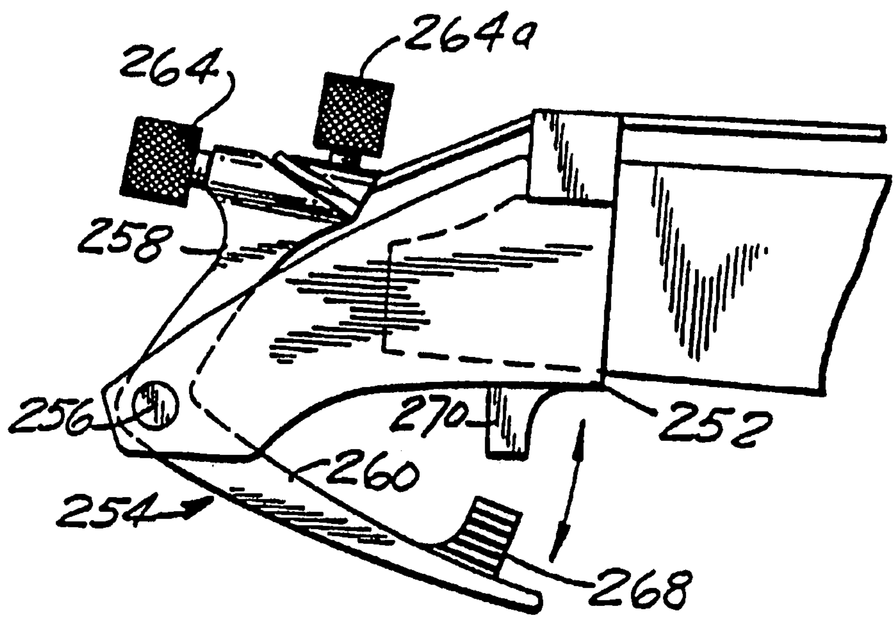



FIG. 11C

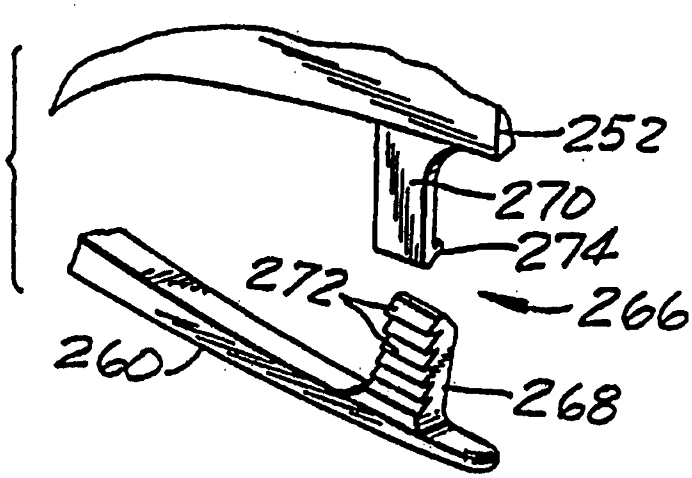



FIG. 11D

# TUNING MEANS FOR STRINGED MUSICAL INSTRUMENT

This is a continuation of application Ser. No. 08/027,729, filed Jan. 14, 1993, which is a divisional of application Ser. No. 07/607,458, filed Oct. 31, 1990, which issued on Mar. 30, 1993 as U.S. Pat. No. 5,198,601, which are each incorporated by reference as if fully set forth herein.

## BACKGROUND OF THE INVENTION

The present invention is directed to the tuning of a stringed musical instrument, such as a guitar. Further, it is directed to the use of free-to-vibrate parts in such an instrument for reinforcing and enhancing the vibrating characteristics of the instrument.

Basically, a stringed musical instrument is a hollow wooden box serving as a support for a number of strings secured in tension on an outside surface of the box. When the strings are plucked or bowed, they produce complex vibrations transmitted through the bridge or string supports to the wooden box causing its various surfaces to oscillate and setting in motion the air within, and surrounding the box, causing audible sound. Obtaining the desired musical effect can be very difficult. In completely acoustic instruments, as compared to instruments using electronic means for amplification and modifying the tone of the instrument, such as those belonging to the violin family and the folk guitar, the wooden box is constructed to oscillate at a number of determined broad resonances for reinforcing the corresponding range of notes played on the instrument. When the tuning of the instrument is maintained, it will have an apparent increase in volume and sustain and generally will be more pleasing to the ear.

In a stringed musical instrument, such as a guitar, the strings extend unsupported between a first critical point on a neck of the guitar and a second critical point on the guitar body. The first critical point is usually formed by a nut supported in the neck. Generally, the second critical point is formed by a bridge element constituting part of a bridge or a combined bridge and tailpiece assembly. Traditionally, the size of the bridge elements is quite small and functions to clearly define the second critical point and can range from a narrow edge to a rounded surface with a diameter no larger than about 5/32". The strings are typically secured beyond the nut by tuning keys and beyond the bridge element by the tailpiece or tailpiece portion of a bridge and tailpiece assembly. Fine tuning the strings has long been a problem for guitars.

In fine tuning or changing the pitch of a string, two different operations are carried out. In one operation, the length of the string between the first and second critical points is adjusted, such as between the nut and the bridge element, and this is known as harmonic tuning. The second operation involves increasing or decreasing the tension on a given string for raising or lowering the string pitch. This second operation is generally characterized as pitch tuning. In practice, initially harmonic tuning is carried out and then pitch tuning.

A problem existing in tuning the strings is that the two different tuning operations tend to conflict. In harmonic tuning, the pitch is lowered when the distance between the critical points is increased and, conversely, when the distance is shortened, the pitch is raised. In pitch tuning, when the tension is increased, the pitch is raised and when the tension is decreased, the pitch is lowered. These different operations present difficulties in pitch tuning and maintaining the tuned condition of a stringed musical instrument.



When a fulcrum tremolo is used, there is the tendency when increasing string tension and raising of pitch, also to increase the length of the string, and, conversely, when decreasing string tension and lowering pitch, also to decrease the string length. Accordingly, when using a fulcrum tremolo, these counteracting features are not always balanced.

With the development of the fulcrum tremolo, that is, where the bridge plate is pivoted to provide a tremolo or vibrato effect, the problem of maintaining an effective pivoting action and assuring the return of the bridge plate to an initial position has presented problems. Often, the solution of one problem in pivoting the bridge plate has resulted in the introduction of another problem. As an example, when the bridge plate is pivoted, there is a tendency to upset the harmonic tuning of the strings. Further, the pivot support of the bridge plate, such as disclosed in the Rose U.S. Pat. No. 4,171,661, presented problems in maintaining the proper pivoting action, in returning to the original tuned position, in limiting the range of pivotal movement, and in maintaining the pivot means free from wear. If pivoting of the bridge plate results in wear of the surfaces at which the pivoting action takes place, friction is introduced into the movement of the bridge plate which interferes with its return to the initial position and original tuning.

Combination bridge and tailpiece assemblies have been known for some time. In the Kaufman U.S. Pat. Nos. 1,839,395 and 2,241,911 and in the Beauchamp U.S. Pat. No. 2,152,738, such assemblies were disclosed affording means for varying the tension on the strings and creating a tremolo effect.

In the Proelsdorfer U.S. Pat. No. 2,304,587, string tensioning devices placed on the tailpiece for fine tuning the pitch of the strings of violins, guitars and the like, were disclosed, however, such pitch adjustment is quite limited in range and designed to offer minor adjustment of pitch rather than raising and adjusting from an untensioned condition the strings by the tuners placed on the head of the instrument.

The first fulcrum tremolo combining the bridge and tailpiece was set forth in the Fender U.S. Pat. No. 2,741,146. In this patent, a bevelled ridge portion of the base plate was secured to the instrument body by six screws for permitting limited pivotal movement about the fulcrum and thereby varying the tension on the strings and producing the desired tremolo effect. The strings were supported in the traditional manner on top of the base plate by bridge elements adjustable in height and for string lengths, that is, harmonic tuning. As in known combination bridge and tailpiece assemblies, the strings extend vertically through openings behind the bridge elements and are secured in the tailpiece which in this case also functions to receive the string tensioning biasing springs.

In the Rose U.S. Pat. Nos. 4,171,661 and 4,497,236, two improvements were established. In one improvement, the bevelled ridge portion of the base plate was arranged so that it could be received and held in a tapered slot between the head of the screw and a flanged shoulder, thereby increasing the range of pitch change and improving the return to the initial tuned position and provided for lateral height adjustment of the tremolo. The other improvement involved functionally and physically integrating the bridge elements with the known art of combining fine tuners with anchoring means. In effecting the fine tuning, the bridge elements were provided with a constant radius, so that harmonic tuning would not be effected when establishing fine tuning, however, fine tuning is limited to a range of about two

musical pitches and is inadequate for bringing the strings to proper pitch for compensating string stretch, or achieving common alternate tuning commonly requiring a larger range of pitch change.

In the Shiboya U.S. Pat. No. 4,383,466, a pin was located in a hinge pivot to improve the return to the initial tuned position. This arrangement did not offer lateral height adjustment of the base plate and the field of rotation was not as great as in the Rose improvement.

With these various improvements, a number of problems remained in the known fulcrum tremolo related to the bridge element and its movement when the tremolo is pivoted. Since the second critical point is offset from the pivot axis, initially there is a tendency for the string height at the bridge to decrease when the base plate is pivoted toward the body with the strings contacting the finger board and causing an undesirable buzzing noise and/or deadening the sound of the strings. This phenomenon limits upward pitch change. In addition, there is a tendency for string length to increase when the pitch is raised and for the string length to decrease with the pitch is lowered acting counter to the desired effect. Furthermore, the different diameters and construction of the strings on the instrument cause the strings to stretch at different rates and lose pitch relationship.

Concerning this last problem, several improvements have been proposed in the Steinberger U.S. Pat. No. 4,632,005, the Jones U.S. Pat. No. 3,411,394 and the Hussino U.S. Pat. No. 4,648,304, however, none of them are directed toward the fulcrum tremolo. In the installation of the fulcrum tremolo, there is a problem in routing the cavity to receive the tremolo. At least one routing has been required for the biasing springs. A further problem experienced in guitars and, particularly, in electric guitars is establishing a formant where the various resonances of the instrument co-act with the vibrations of the strings to enhance playing quality. Due to centuries of trial and error in the development of the violin body, a very sophisticated formant has been achieved. This has not been the case for the guitar. Particularly in electric guitars, the wooden box can cause unwanted feedback, so that volume of the cavity in the wooden box is often reduced or completely eliminated, as in the case where a solid body is used. As a result, electric guitars depend greatly on electrical amplification for both volume and tone. In the current design theory of electric guitars, the use of metal and especially of steel bridges contribute such mass that it prevents what little resonances the rest of the instrument possesses from having much effect. Accordingly, the tone of such instruments is limited for the most part by the vibrational characteristics of the strings. Another problem is that some players tend to rest their hand on the fulcrum tremolo while playing and inadvertently move the tremolo and detune the instrument.

In stringed musical instruments, the vibration of the strings in combination with the other parts of the instrument, combine to provide the desired tone or sound of the instrument. In the U.S. Patent to J. D. Webster, U.S. Pat. No. 3,353,433, a tuning fork is incorporated with a floating bridge arrangement. The bridge arrangement depends from the tuning fork and is supported entirely by the strings of the instruments. Accordingly, when the strings are plucked and set into motion the tuning fork is activated and in turn feeds energy back through the bridge arrangement to the strings, the purpose of which is to keep the strings vibrating as long as the tuning fork vibrates. However, the actual pitch and strength or the vibrating of the tuning fork were not adequately considered and the result was unbalanced at best.

In conventional stringed instruments tuning pegs secure the strings at the head of the instrument. The pegs have an opening through which the string is passed and then tied. Problems exist for conventional peg tuning, such as the amount of peg tightening required and the need for adjustment to compensate for on-going tuning and normal string stretch which takes place during use. As a result, fine tuners have been provided on the bridge or tailpiece. Further, often there is a relatively long distance between the nut and the tuning pegs where the string bends causing unequal tension on opposite sides of the nut and tuning problems. One proposed solution employs string clamps on the nut, however as often happens the string stretches beyond the adjustment range of the fine tuners. Accordingly, the required correction is tedious and time consuming involving unclamping, readjusting of the clamp, retuning, reclamping and further readjustment.

## SUMMARY OF THE INVENTION

Therefore, one primary object of the present invention is to provide a stringed musical instrument with an improved arrangement for both harmonic tuning and fine tuning of the instrument.

Another primary object of the invention is to provide a sophisticated set of tuned resonances added to the bridge or the combination bridge and tailpiece assembly of the stringed musical instrument, as a functional analogue to the sophisticated formants found in the violin which improve the sustain and resonant quality of the instrument.

Common objects, such as an odd shaped piece of metal when dropped or struck, and set into vibration, usually have an unpleasant or harsh sound. This is characterized by a low tone referred to as the fundamental which can be one specific frequency or several frequencies defining a broad resonance and higher tones or secondary resonances referred to as harmonics. The irregular mathematical relationship between the frequencies of these tones causes the harsh sound as reflected by the irregular shape of the object.

In the case of a metal bar with parallel sides the tone is more pleasing and by removing mass from the middle of the bar the frequencies of higher tones can be tuned to whole number multiples of the frequency of the lower tone as is done in marimbas and xylophones, and the like.

In another variation, strips of metal tightly coupled at one end to a gourd or a similarly fashioned hollow object comprise the African "thumb piano", however, there has been no effort to tune the upper tones to the lower tones and such metal tines are directed to producing tones for the instrument, like the strings on a guitar for example, and not for the modification of the resonances of the hollow portion, like the body of the stringed instrument such as a violin. It is known that such a bar tightly coupled at one end has two higher tones that are $6.27 \times F_1$ (fundamental) and $17.55 \times F_1$, respectively. The tuning fork is actually two bars joined together at one end with each vibrating at approximately the same fundamental. When the fork is tightly coupled to another object the second harmonic drops very close to the fundamental and communicates its vibratory character to the object to which it is coupled. Single bars communicate an influence dependant on the ratio of mass between the bar and the object it is coupled to.

As with the bars of the xylophone, changing the shape of the vibrating object tightly coupled at one end creates the means for functionally tuning its resonant frequencies.

The overall length of the free-to-vibrate portion generally defines the frequency of the lowest tone. Transverse slots can be used to define length. A blind bore in the free end can define the effective length as well.

If the opposite surfaces are tapered toward one another the lowest tones form a broad resonance comprised of many weak frequencies surrounding a strong frequency. Parallel surfaces create one focused low frequency. Removing mass is another way of tuning the higher tones. These recesses can be holes, and when placed close together can form "oval" openings or expanded to slots. Added weight can be used to lower the fundamental resonances whether permanently affixed or adjustable in position.

These means of modifying the character of bars tightly coupled at one end are applicable to changing harmonic content of tuning forks.

A tuning fork or tuning fork-like apparatus of sufficient mass can redefine the resonances of any object to which it is tightly coupled. Additional free-to-vibrate portions of sufficient mass can be tightly coupled to the tuning fork-like apparatus for adding additional resonances. Such a combination can be effective in defining the resonant qualities of any object subject to vibration such as musical instruments.

A further object is to provide individual intonation modules for each string of the instrument affording separate means for the adjustment of harmonic tuning of the bridge portion of the module and macro-tuning of the string attached to the tailpiece portion of the module providing the capacity to bring the strings to proper tension and a tuning range of greater than an octave for use with but not exclusive to "headless" stringed musical instrument, that is, instruments without tuners placed on the head of the instrument.

A further object is to provide two tapered free-to-vibrate portions approximately the same and each with two holes for creating secondary resonances two and three times the strong frequency in the broad resonance and each of approximately the same fundamental resonance tightly coupled to one another and to a musical instrument such that the responsiveness of the musical instrument is defined with no significant resonant peaks or dips other than those created by this tuning fork-like portion.

A further object is that the strong frequency of the tuning fork-like portion is tuned to a pitch of the instrument. For example, it could be a B♭ (B Flat) for a B♭ saxophone or $E_2$ or whole number multiple thereof, specifically for this embodiment designed for guitar.

A further object is that the adjustment of the strong frequencies of the tuning fork-like portion is effected either by a set screw in a blind bore in the free end or by a slidable member.

Yet another object, in addition to the tuning fork-like portion, is to provide six additional tapered free-to-vibrate portions coupled to a musical instrument each with a long slot and a broad resonance of an effective range covering a major third (for example concert C to E on the piano) and which strong frequency is tuned between two pitches, (for example between concert C and D flat on the piano) and which slot creates secondary resonances in whole number multiples of the strong frequency.

A still further object is to provide each of six additional free-to-vibrate portions with a different strong frequency spaced a major third from each other and in concert with the secondary resonances, for reinforcing each note on the instrument in a balanced sensitive and responsive manner. The strong frequency in the broad resonance in the series can be tuned to between 220 hz and 390 hz.

Yet another object of the invention is to provide an improved bearing arrangement for a fulcrum tremolo for assuring the proper and wide range of pivotal movement of the tremolo while limiting wear or friction which would tend to defeat the effectiveness of the tremolo.



Still another object is to provide means for limiting the pivoting of the tremolo towards the body.

An additional object is to provide free-to-vibrate portions for a broad range of devices.

In the description of the invention, the following terms are used and are defined to assure a proper understanding of the terminology employed.

Resonance refers to vibrations of large amplitude within an object subject to vibration, such as a stringed musical instrument. Other instruments or apparatus are also subject to vibration. In the following description of the invention an electric guitar is used as the item subject to vibration however, the invention is also applicable to other vibration instruments and apparatuses.

Resonant frequency is the frequency of an object subject to vibration when set into motion such that it produces a greater response.

Concert tuned pitch is a pitch derived from a commonly accepted standard, for example, A=440 hz.

The musical interval of a major third is the distance of five musical tones, for example, concert C to E on the piano.

Macro-tuners refer to tuners with the capacity to raised and adjust from an untensioned condition strings to proper playing pitch, providing for alternate tunings, and compensation for substantial string stretch during the life of the string essentially without additional means.

Resonant frequencies are the frequencies where the object subject to vibration has more than one mode of vibration.

Fundamental resonant frequency is the lowest resonant frequency in an object subject to vibration.

Secondary resonant frequencies are the frequencies other than the fundamental.

Overtones, or partials, are resonances of various amplitudes above the fundamental resonant frequency.

Coupled is the connection provided between two vibrating objects which influence one another when they are subject to vibration. The coupled condition can be a loose coupling where the resonances of each object remains unchanged or a tight coupling where the resonances of each object interact very strongly.

Hertz is a unit of frequency of a periodic process equal to one cycle per second.

$E_3$ is usually defined as 164.81 hz when $A_4$ is defined as 440 hz by the International Standards Organization; although in Europe and other parts of the world $A_4$ can vary by up to 25 hz. By this standard $B\flat_3$ is 233.08 hz, $B_3$ is 246.94 hz, $D_4$ is 293.66 hz and E♭ is 311.13 hz, etc.

Free-to-vibrate refers to a tuned member coupled to another member and having a portion not coupled or in engagement with the other object.

A tuning fork has two tightly coupled free-to-vibrate bars or sections of approximately the same frequency for creating one fundamental resonance frequency with the first harmonic very close to the fundamental and a second harmonic approximately sixteen times the frequency of the fundamental frequency so that no resonant peaks or dips are present between the fundamental resonant frequency and the harmonics. A tuning fork also has the capacity to impart these characteristics to any object to which it is tightly coupled.

A formant is a fixed array of resonances in which the frequency of the harmonics of the object subject to vibration are emphasized regardless of the fundamental frequency of the vibrational influence on the object.

In a guitar, the strings extend unsupported between a first critical point at the nut mounted in the neck of the guitar and a second critical point at the bridge mounted on the body of the guitar.

In accordance with the present invention, a guitar, preferably an electric guitar, has a body with a neck extending outwardly from the body; usually six strings extend at least from the nut on the neck spaced from the body to some form of anchorage beyond the bridge and mounted on the body. A fulcrum tremolo assembly is mounted over a cavity in the body so that a part of the assembly can be pivoted into the cavity when the tremolo is actuated.

The bridge and tailpiece assembly includes a base plate mounted on the body. The base plate mounts six intonation modules, each arranged to secure one of the strings in its tailpiece portion and to effect the harmonic tuning of the strings. In addition, a wing-like member is located along each of the sides of the base plate, extending in the direction of the strings. Each wing-like member has a first end closer to the neck and a second end more remote from the neck. Adjacent the first end, the wing-like member is directly connected or tightly coupled to the base plate. The wing-like member has a section extending in the direction of the strings from the connected part, away from the neck. The wing-like section has a lower surface facing the body and the lower surface can be tapered upwardly to the rearward free end of the section. The wing-like members are located laterally outwardly from the cavity in the body. Because of their shape, when the bridge plate is pivoted, the wing-like members do not interfere with the pivoting action and do not contact the surface of the body In the intonation modules the bridge element is functionally separate and physically distanced from the tailpiece portion.

At the connected first end of the wing-like members, the base plate is pivotally supported in a bearing assembly containing ball bearings adjustably mounted so that the plate can be variably spaced from the surface of the body. The bearing assembly includes a self-aligning means to accommodate the variable adjustment of the base plate. Further, instead of at the sides, it is possible to locate the pivot point or pivot axis for the base plate along the front side of the plate facing toward the neck.

Also by using self-aligning bearings or a bearing affording a universal joint type movement, it is possible effectively to pivotally support the base plate, when its axis is not parallel with the surface of the body.

As compared with the knife-edge pivot support of the fulcrum tremolo disclosed in the Rose U.S. Pat. No. 4,171,661, it is possible to limit the wear of the bearing so that unnecessary friction is not developed which would interfere with the return of the base plate to its initial position. In its initial position, the base plate is fine tuned. When the tremolo is pivoted to provide a vibrato effect, the tension on the strings is increased or decreased. When the tremolo arm is released, the tremolo should return to its initial position so that its fine tuned condition is maintained. If the bearing arrangement for the base plate should prevent its return to the initial position, then further adjustment would be needed. In accordance with the present invention, however, ball bearings assure that the bridge assembly returns to the initial position and that wear does not take place which would interfere with the pivotal movement, and of offers a greater field of rotation for the largest possible pitch change.

Existing acoustic physics indicates when two vibrating objects are "tightly" coupled, the resonances of one will influence the resonances of the other. A free-to-vibrate portion of an object set into motion will adopt a resonant frequency and resonances defined primarily by its length and mass. The addition or reduction of mass and its subsequent location along a defined length will change the pitch of the



resonant frequency and resonances. Accordingly, the resonant frequency and resonances of an object can be changed based on the characteristics of the free-to-vibrate portion of the other object. As a result, by selecting the structure of the free-to-vibrate portion, it is possible to adjust resonant frequencies in objects subject to vibration.

The control of vibrations has a broad application, not only in musical instruments, such as stringed instruments, but also in speakers and microphones. Moreover, for creating less conflicting energy, such as in engines for vehicles such as motor cars. The control of vibrations can be employed in any device subject to vibration, particularly where the vibrations may tend to have a deleterious effect.

The use of free-to-vibrate portions or elements has preferred application in musical instruments, especially stringed musical instruments.

Musical instruments have tuned resonances for augmenting the energy of a vibrating source. In stringed instruments, a hollow box, usually a wooden box, serves as a support for a number of strings maintained under tension. The box is designed so that its surfaces oscillate producing vibrations in the air within and surrounding it, so that the sound of the vibrating strings are amplified and audible. The oscillating surfaces are arranged to have resonances for reinforcing the vibrations of the strings. In accordance with the present invention, the various parts of the bridge and tailpiece assembly are arranged to enhance the vibrations of the strings.

Various parts of a stringed musical instrument can be selectively configured so as to be free-to-vibrate for augmenting the vibration of the strings, that is, to amplify the energy of the strings. In a preferred embodiment, the free-to-vibrate portions are particularly effective when coupled with the strings or with the bridge elements.

In electric stringed musical instruments, such as electric guitars, the body, which in some instances may not be hollow, does not contribute substantially to the amplification of the instrument. In such instruments, the bridge does not function to transfer the energy of the vibrating string to the body for amplification, rather it reflects the energy back to the string where it is picked up by an electromagnetic device and amplified electronically. However the use of the bridge for establishing resonances can be most effective when coupling of various free-to-vibrate portions create resonances for reinforcing the vibration of the strings in a manner analogous to the reinforcing effect of a hollow body in a purely acoustic instrument. Since the over-all tonal character of any instrument is effected by the choice of materials, size and shape, and other structural features, the resulting pattern of resonances, its "formant" can be adjusted by these various features to reinforce or modify the sound of the instrument to suit a player's needs.

Free-to-vibrate portions can be a part of the wing-like members on the base plate, a part of the intonation modules mounted on the base plate, part of the structure of the base plate, or other parts connected to the instrument.

The free-to-vibrate portion can be shaped to provide the requisite fundamental resonant frequency. The shape of the free-to-vibrate portion can be a tapered member with the tapering surface being planar or curved. Moreover, weights can be added to the free-to-vibrate portion or mass removed for tuning the fundamental resonant frequency to provide the desired effect. It is also possible, where the free-to-vibrate portion affords its use, to mount a slidable member securable by a set screw on the portion for varying the frequency.

While free-to-vibrate portions can be used for effecting a formant in a stringed musical instrument, such parts can also

be employed for controlling the vibration of other objects, such as an automobile engine or even a building or other large structure. In the operation of an automobile engine, or of many other mechanical devices, it is possible for vibrations to develop which have a deleterious effect on the continued operation of the device. By providing the proper free-to-vibrate portions on a vibrating device, the range of vibrations can be kept within certain limits or tuned for limiting or avoiding damage.

A significant feature of the use of the free-to-vibrate portion is that it is tightly coupled to the vibrating object for achieving the desired result. As pointed out above, the wing-like member forming the free-to-vibrate portion, is formed integrally with the base plate. Without the tightly coupled connection, the influence of the free-to-vibrate portion is not achieved.

Another preferred feature of the invention is the arrangement of the intonation modules on the base plate for providing harmonic and pitch tuning of the individual strings and also for influencing the vibration of the strings by incorporating free-to-vibrate portions as a part of the intonation modules.

The intonation modules are slidably mounted in slots in the base plate for effecting the desired harmonic tuning, that is, for fixing the string length between the first and second critical points. Each intonation module can be separately locked in position establishing the desired length between the critical points.

The second critical point is formed by a bridge element constructed as a part of the intonation module, though it is functionally separate from the rest of the module. The bridge element is connected to a base elongated in the direction of the strings. The base is slidably connected to the base plate and is secured to the base plate after the harmonic tuning is effected. The intonation module base has a front or first end on which the bridge element is formed and it extends away from the bridge element toward the rear end of the body, that is, the opposite end from the neck. The bridge element forms the second critical point. An important feature of the bridge element is its varied curved surface contacted by the string.

A significant feature of the invention is the manner in which the curved surface is formed. In the initial position of the tremolo, the second critical point divides the curved surface into a first section closer to the neck and a second section more remote from the neck. When the base plate is pivoted, the intonation modules and, as a result, the bridge elements pivot with it so that the location of the second critical point changes, increasing or decreasing the tension on the strings. Since the strings each have a different cross-sectional size, there is a variable tensioning effect on the strings. To maintain the fine tuned character of the strings relative to one another, each of the enlarged curved surfaces of the bridge elements are varied relative to one another so that each of the second critical points travels along the surface in differing distances and thereby selectively changing the harmonic tuning. By providing the proper ratio between each of the enlarged curved surfaces on each of the bridge elements, it is possible to compensate for uneven string stretch and maintain the relative harmonic tuning between the strings during the pivoting movement of the tremolo. Furthermore, by increasing the radius of the first section relative to the radius of the second section the upward pitch change can be further augmented. Lastly, by varying the radii continuously a smooth transition from the first section to the second section can be achieved.

Another important feature of the invention is the increase radial size of the bridge elements for maintaining the string



height relative to the fingerboard when the tremolo is used. Accordingly, the bridge elements cannot contain rotatable parts since harmonic tuning would be disturbed in the initial position. Consequently, the bridge elements must be functionally separate from the tailpiece. Further, the strings must slide over the bridge elements during change of tension in the fine tuning.

Another object of the invention compared to the prior art is to provide a shortened spring -block or the base plate, moved rearwardly and fitted with smaller string tension biasing springs, so that the whole assembly can be fitted into a single cavity in the body of the instrument below the base plate. This feature simplifies routing of the body.

Still another object of the invention is to provide a stepped base plate and shims for adjusting the height of the bridge elements and for maintaining tight coupling between the bridge elements and the base plate.

Each intonation module has a lever-like time member pivotally connected to the base adjacent the bridge element, with the tine member extending from the pivot point toward the rear end of the guitar body. A passage is provided through the tine member for receiving the string after it passes over the bridge element, with the string being anchored at the rear end of the passage in the tailpiece part. By pivoting the tine member, the tension on the string can be varied. The pivoting of the lever-like tine member, can be effected by an adjustment member mounted on the base.] The tine member has a curved surface extending toward the rear end of the body. The adjustment member can be threaded into the base and into contact with the curved surface and such contact causes the lever-like tine member to pivot about its connection to the base. As a result, the orientation of the passage through the lever-like member can be altered so that:the tension of the string passing through it is also changed. Further, the forward tips of the lever-like tine pivot under the bridge element for dramatically increasing the potential of the tension effected by the adjustment member. Accordingly, macro-tuning of the individual strings can be achieved by the adjustment member.

It is also possible to form a rear part of the lever-like member as a free-to-vibrate portion for adding resonances to the bridge and tailpiece assembly. The free-to-vibrate portion of the lever-like tine member can be shaped to provide the desired fundamental resonant frequency. The combination of the free-to-vibrate portions on the base plate and in the intonation modules provide a formant in the instrument.

The base plate is formed of a first part extending generally parallel to the surface of the guitar body and a second part disposed perpendicular to the rear end of the first part and extending downwardly from it into the recess in the body. The second part is connected to spring means within the cavity for effecting the return of the tremolo or bridge assembly into the initial position after the tremolo has been pivoted and released.

The tremolo is pivoted by a tremolo arm secured to one wing-like member of the base plate. An insert is formed in the wing-like member into which the tremolo arm can fit.

To avoid accidental displacement of the tremolo arm, a releasable lock secures it in its initial position until the tremolo arm is to be intentionally pivoted.

Still another significant feature of the invention is the creation of a sophisticated set of tuned resonances in the bridge or the bridge and tailpiece assembly of a stringed musical instrument. In one preferred embodiment, means are provided for creating a formant in the vibration of the guitar as it is played. The desired effect can be achieved by using

tapered free-to-vibrate portions tightly coupled to the bridge or bridge and tailpiece assembly. With at least two tapered free-to-vibrate portions each having a broad resonance and a strong central resonance frequency adopting characteristics of a tuning fork, the second harmonic drops from approximately six times the fundamental to within a few Hertz of the fundamental removing any other resonant peaks or dips, other than the third harmonic which relatively is not influential for the bridge mass, since this tuning fork-like apparatus vibrates for an extended period it will keep its secondary resonances created by two cylindrical holes in each tapered free-to-vibrate portion and any other free-to-vibrate portion coupled thereto vibrating and active.

In addition, six other free-to-vibrate portions or tine members are arranged as part of the intonation modules, each tuned to have a broad resonance with its own harmonics or secondary resonances. When secondary resonances from any two or more tine members are placed close to one another harmonically, they simulate the effect of a fundamental broad resonance. By properly tuning the tine members, the tuning fork portions, and their secondary resonances, a formant is established, fully reinforcing the vibrations of any note played on the instrument in a balanced manner and providing exceptional volume, tone and sustain as in great violins.

Since the free-to-vibrate portions are tuned to react with a wide range of frequencies, they act like sensitive antennae vibrating sympathetically to the sound produced by the speakers in the electric amplification means. This increased sensitivity allows for outstanding sustain with lower amplifier distortion at lower playing volumes than would be otherwise possible.

Aluminum alloys are particularly effective in forming the free-to-vibrate portions and afford greater sensitivity than other materials. Stainless steel can also be used for any of the parts of the bridge, or bridge and tailpiece assembly, due to their ability to couple extremely well. Further, stainless steel is relatively free from wear.

Although the invention is described with respect to metal guitar bridges and more specifically fulcrum tremolos, it is equally possible to create free-to-vibrate portions out of wood or synthetic materials such as reinforced graphite, especially for use in purely or semi-acoustic instruments.

Choice of materials in the construction of musical instruments has always been important. As scientific advances and new developments in materials continue to evolve at a brisk rate, their application can be directed to the use of free-to-vibrate portions coupled to musical instruments.

The use of steel, brass and bronze is very common in musical instruments and steel has become the favored material for stringed musical instrument bridges, because of its bright sound, great mass and durability. Accordingly, steel is a suitable material for the present invention, however, for the first time aluminum can be utilized as it shares the same stiffness to mass ratio as steel but will afford a softer sounding, more responsive and resonant response and, depending on the player, may be preferred.

Further, recent advances in ceramics have been outstanding and have produced entire automobile engines. Commercial applications of ceramics are becoming increasingly common in everyday life, for example, reasonably priced bells and knives are available where steel has been replaced by ceramic materials. As ceramics are more readily moldable and offer acoustic properties similar to steel, they can be used for all bridge parts from the intonation module base to the free-to-vibrate portions.



In some applications, particularly those directed toward non-electric or purely acoustic instruments, other materials may be desirable. Certainly, wood is the most obvious choice, throughout history its superior qualities have been demonstrated. Plastics and composites, such as graphite epoxy, have been used successfully to create sound boards for guitars and violins where the mechanical properties of a composite sandwich plate with graphite-epoxy facings and a low density core closely matched those of a conventional spruce plate. Such materials could be used effectively and economically to produce high quality free-to-vibrate resonant plates and bridges of a consistent level.

Another primary object of the present invention is to provide an adjustment device for bringing the strings to pitch at one of several coarse tunings quickly and then fine tuned by separate means.

A tuning adjustment device is provided for securing the string at the head of the instrument and then making a fine tuning adjustment by means of a thumb screw. The tuning device is pivoted on the head end of the stringed instrument and is movable between several tensioned positions and a untensioned or released position. In the tension position the anchorage for the string is located relatively close to the nut at the head end of the instrument so that little bending of the string takes place.

The tuning device is formed as a two armed L-shaped lever pivotally mounted on a bracket secured to the head end of the instrument in the region of the nut. The string is secured at a free end of one arm of the lever and a locking means for the device is provided adjacent the free end of the other lever arm. The locking means is in the form of a forceps-like clamp containing a plurality of teeth so that each tooth provides a different locking position. By changing the locking position the tension on the string can be quickly increased or decreased as required for providing preset pitch changes.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a plan view of an electric guitar embodying the present invention;

FIG. **2** is a perspective view of a tremolo-bridge-tailpiece assembly as used in the guitar of FIG. **1**;

FIG. **3** is an exploded perspective view of the tremolo-bridge-tailpiece assembly in FIG. **2**;

FIG. **4A** is a side view of the bridge-tailpiece assembly of FIG. **2**;

FIG. **4B** is a partial plan view of the bridge-tailpiece assembly of FIG. **3A**;

FIG. **4C** is a partial end view of the bridge-tailpiece assembly of FIG. **3A**;

FIGS. **5A** and **5B** are side views illustrating the range of displacement of a lever member in the intonation module;

FIGS. **6A–F** are cross-sectional views of the different bridge elements mounted on the intonation modules as shown in FIG. **1** and FIG. **2**;

FIGS. **6G** and **6H** are schematic illustrations of a bridge element showing the prior art;

FIGS. **6I** and **6J** are schematic illustrations of the bridge elements of the present invention;

FIG. **7A** is a side view, partly in section, of a retractable tremolo limiter in a limiting position;

FIG. **7B** is a side view, similar to FIG. **7A**, however, showing the tremolo free to pivot;

FIG. **8A** is a partial side view of a guitar with a "bolt-on" neck;

FIG. **8B** is a view similar to FIG. **8A** with a flat shim;

FIG. **8C** is a view similar to FIG. **8B** with a wedge shim;

FIG. **9A** is a side view of an engine with an attached free-to-vibrate section;

FIG. **9B** is a view of a building frame with a free-to-vibrate portion;

FIG. **9C** is an enlarged detail view of the encircled part in FIG. **9C**;

FIG. **10A** is a perspective view of an acoustic guitar with a resonance bridge;

FIG. **10B** is an enlarged partial plan view of the acoustic guitar and resonance bridge;

FIG. **10C** is a side view of the acoustic guitar and resonance plate;

FIG. **10D** is a plan view of the resonance plate separate from the bridge;

FIG. **11A** is a plan view of a plurality of adjustment tuning devices for use on a stringed instrument;

FIG. **11B** is a side view of one of the devices shown with the string in the tensioned position;

FIG. **11C** is a side view, similar to FIG. **11B**, however, with the string in the unlocked or released position; and

FIG. **11D** is a detailed view, on an enlarged scale, of a locking means for the device.

## DETAILED DESCRIPTION OF THE INVENTION

In FIG. **1**, an electric guitar **1** is illustrated comprising a head **2** at one end, a body **3** at the other end, with a neck **4** extending between the head and the body. Six strings **6** extend from the head **2** to the body **3** over the neck **4**. The neck **4** forms a fret board **8** for the guitar. At the head, each of the strings extends over a nut **10** forming the first critical point for the strings. The nut **10** is located at the transition from the neck **4** to the head **2**. Each of the strings **6** is anchored on the head by an anchor **12** and each anchor has a corresponding tuner or tuning peg **14**. On the body **3**, the strings **6** are secured to a bridge-tailpiece assembly **16**. The bridge-tailpiece assembly is a fulcrum tremolo with an arm **18** for pivoting the fulcrum tremolo and providing a vibrato effect on the strings. The bridge-tailpiece assembly **16** includes six intonation modules **20**.

In the body **3** of the guitar there are electric pick-ups.

In the following description, the bridge-tailpiece assembly **16** will be described in greater detail.

The bridge-tailpiece assembly **16** forms a second critical point for the strings **6**, sometimes characterized as an intonation point or bridge point.

In FIG. **2**, the bridge-tailpiece assembly **16** or fulcrum tremolo is shown on an enlarged scale as compared to FIG. **1**. FIG. **3** displays the bridge-tailpiece assembly **16** of FIG. **2** in an exploded view. The second critical point is located at the front end of the assembly **16** extending across the bridge elements **24**. There is a separate bridge element **24** for each of the intonation modules **20**. Outwardly from the intonation modules **20** on each side of the opposite sides extending in the string direction, there are two wing elements **26**. The wing elements **26** are formed integrally with a main stepped plate **28**. Each of the wing elements **26** is supported on a bearing housing **30**. The bearing housings **30** pivotally support the stepped base bridge plate **28**. The tremolo arm **18**, shown only in part, is secured within an arm insert **32** and pivots the assembly **16** relative, to the bearing housings **30**.



Each wing element **26** is secured integrally with the main bridge plate **28** in the region of the bearing housing **30** and the arm insert **32**. Immediately behind the arm insert **32** are slits **34** extending transversely of the long direction of the wing elements, that is, transversely of the direction of the strings **6**, and partially separating a free-to-vibrate portion **36**, from the portion of the wing element **26** secured to the stepped base plate **28**.

As can be seen in FIG. **9**, the body **3** has a routed opening **38** located below the bridge-tailpiece assembly **16**, with a spring block **40** secured by bolts **41** to the stepped base plate **28** and extending downwardly from it, into the routed opening **38**. A spring plate **42**, shown only schematically, is secured within the routed opening **38** below the stepped base plate and spaced slightly rearwardly from the bridge elements **24**. Springs **44** extend between the spring plate **42** and the spring block **40** for returning the bridge-tailpiece assembly **16** back to its original position, after it has been pivoted by the tremolo arm **18**.

The wing elements **26** extend generally parallel with the intonation modules **20** and with the strings **6**. Each wing element **26** is pivotally supported by its bearing housing **30**. The forward portion **46** of the wing element **26**, located closer to the neck **4**, is formed integrally with the stepped base plate **28**.

The forward portion **46** of the wing element **26** is fairly massive, while the rearward portion **48** tapers from the forward portion, separated partly from it by slits **34**, into a relatively thin section forming the free-to-vibrate portion **36**. Transverse to the string direction, the wing elements **26** are relatively wide, being somewhat wider than the intonation modules **20**. The rearward portion **48** or free-to-vibrate portion **36** is separated from the stepped base plate **28**.

The free-to-vibrate portion **36** is shaped to provide the desired resonance for enhancing the vibration of the strings and improving the tone of the guitar. The free-to-vibrate portion **36** can have curved or tapered surfaces. In addition to the shape of the free-to-vibrate portion, the desired resonance characteristic can be achieved by drilling single or multiple holes **26***a* in the portion, and by adding mass to or removing mass from the portion **36**. The holes **26***a* can be joined together to form elongated slots intermediate the ends of the free-to-vibrate portion or extending from the free end toward the coupled end. In FIG. **3** a set screw **26***b* is inserted into a threaded hole, not shown, for fine tuning the pitch of the free-to-vibrate portion.

In FIGS. **2**, **3** and **4A–4C**, the bearing housing **30** is shown at the forward end of the wing element **26**. The bearing housing **30** fits into a cut-out **50** in the forward end of the wing element **26**. The housing **30** is adjustably supported relative to the body **3** of the guitar by a threaded post **52** with annular flange **52***a*. Post **52** is threaded into a housing insert **54** in the body **3** of the guitar, note FIGS. **4A** and **4C**. By adjusting the extent of the threaded engagement for the post **52** into the body insert **54**, the spacing between the body **30** and the surface of the body **3** is selectively adjustable. Adjustment of the post **52** is effected through an oval

opening **30***a* in the top of the housing **30**. The oval shape permits relative movement between the post **52** and the housing **30**. A set screw **30***b* fits into the rear end of the housing **30** to secure the post **52**. In the housing **30**, forwardly of the post **52**, there is an opening through the housing extending transversely of the string direction of the guitar containing a quad-stack bearing assembly **56**, formed by four side-by-side roller bearings **58**. A pin or shaft **60** is threaded into one side of the wing element **26** and extends through the bearings **58** into the wing element on the opposite side of the recess **50**. Accordingly, by manipulating the tremolo arm **18**, the bridge-tailpiece assembly **16** or fulcrum tremolo can be pivoted about the pin **60** to achieve the desired effect when playing the guitar.

While a quad-stack bearing assembly **56** is shown for pivotally supporting the bridge-tailpiece assembly **16**, a variety of pivot bearings could be employed. A significant feature is that the bearing assembly permits the displacement of the bridge-tailpiece assembly with the pivot axes of the pins **60** not parallel to the surface of the body **3**. This feature is important when the bearing housings **30** on the opposite sides of the bridge-tailpiece assembly each have a different height above the body surface of the guitar.

As shown in FIG. **3**, the sleeve-like arm insert **32** is threadably secured in the forward portion **46** of the wing element. The arm **18** is threadably secured in the insert. By means of the arm, the bridge tailpiece assembly **16** is pivoted.

In FIG. **3**, the main bridge plate **28** is shown with the attached wing elements **26**. Note that the free-to-vibrate portions **36** are separate from the main bridge plate and are partially separated from the forward portion **46** by the slits **34**. The main bridge plate **28** includes the spring black **40** located at the rearward end of the plate, that is, the end more remote from the neck of the guitar.

Approximately in line transversely of the string direction with the insert **32**, are six rectangular openings **78**, note FIG. **3**. Each of these openings receives a projection **89** of each of the intonation modules **20** to be described later.

In FIG. **3**, a portion of the tremolo arm **18** is shown extending upwardly from the insert **32** for effecting the pivoting action of the bridge-tailpiece assembly **16**. The spring block **40** is provided with screw holes **80***a* aligned with screw holes **80***b* in the base plate **28** to receive bolts **41** for securing the block to the plate. The springs **44** are secured to and extend between the spring plate **42** and the spring block **40**. The springs **44** return the bridge-tailpiece assembly **16** to its original position after the tremolo arm **18** is released following pivotal displacement of the assembly.

In FIG. **3**, one of the intonation modules **20** is shown, including a base **82** with a bridge element **24** located on the right hand end of the base. A lever member **84** is pivoted to the base by a pivot pin **86**. The base **82** is adjustably secured to the spring block **40** of base plate **28** of the bridge-tailpiece assembly **16** by a bolt **88** and spring **88***a*. The bolt **88** is supported in the spring block **40** and is threaded into projection **89** on the base **82** extending through an opening **78**. Spring **88***a* encircles the bolt **88** between the block **40** and the projection **89**. By turning the bolt **88** the position of the intonation module relative to the base plate **28** can be adjusted. As can be seen in FIG. **2**, the openings **78** are elongated in the string direction and permit adjustment of the intonation module in that direction for effecting harmonic tuning. The positions of individual intonation modules can be adjusted by turning the bolts **88**. The projecting **89** is secured at the under side of the base plate **28** by a washer **89***a* and a bolt **89***b* threadably secured and into the underside of the base **82**.

The bridge element **24** has a recessed variably curved portion **24***a*, note FIG. **3**, in which the corresponding string **6** seats as it moves over the bridge element. From its point of contact with the bridge element **24**, that is, at the second critical point, the string **6** moves downwardly into an elongated passageway **90** extending first through lever member **84** and then through the base **82** from adjacent and just rearwardly of the bridge element **24** to the rearward end of the base, note FIGS. **5A** and **5B**. At the front end of the lever member **84**, at the entrance into the passageway **90** there is a stainless steel sleeve **84***b* which forms a wear resistant surface for the strings **6**. At the rearward end of the passageway **90**, an enlarged recess **91** in the base **82** is provided for an anchor **92** securing the ball end of the string **6**.

An adjustment screw **94** is threaded into the rearward end of the base **82** into engagement with a surface **96** of the lever member **84**. In FIG. **5A**, the adjustment screw **94** contacts the surface **96** so that the string **6** is in contact with the surface **96** at its intersection with the passageway **90**. This position is the rearwardmost point of contact of the string within the passageway **90** with the lever member **84**.

In FIG. **5B**, the maximum range of upward displacement of the lever member **84** is shown. As the lever member **84** is pivoted upwardly by threading the adjustment screw **94** forwardly into the base **82**, the sleeve **84***b* in the forward end of the passageway **90**, that is, the forward end of the lever member **84**, contacts the string **6** and presses it downwardly providing an adjustment in the pitch tuning of the string by varying the tension or pull exerted on the string. The contact of the string **6** with the surface of the corresponding bridge element **24** is also varied. As the adjustment screw **94** is moved between the two limiting positions, shown in FIGS. **5A** and **5B**, the tension on the string **6** is varied.

The lever member **84** has a free-to-vibrate portion **98** formed by a slit **100** in the lever member extending in the string direction from a rearward part of the surface **96** to a point approximately above the pivot pin **86**. Slits **102** extending transversely of the slit **100** pass through the lever member connecting the slit **100** with the upper surface of the lever member. The slits **102** can be seen in FIGS. **2**, **3**, **5A** and **5B**. The free-to-vibrate section **98** of the lever member **84** extends from the slits **102** to the rearward end of the lever member **84** where the free end **84***a* is enlarged to form a mass **106** for obtaining the desired resonance effect for the lever member. Slots **98***a* can be formed in the broad surface of the free-to-vibrate section **98** of the lever member **84** for achieving the desired resonance effect.

While only a single intonation module is illustrated in FIGS. **3**, **5A** and **5B**, the lever members **84** for each of the intonation modules can be selectively shaped to afford the desired resonance effect for the whole bridge tailpiece assembly. The combination of the resonance effects of the lever members **84** added to the resonance effects of the tuning fork-like tapered wing elements **26** provides a formant for the guitar not previously attainable.

In the bridge-tailpiece assembly **16**, the tailpiece afforded by the rearward end of the base **82** of each intonation module **20** is functionally separated from the bridge element **24** located on the forward end of the corresponding intonation module.

In the past, any adjustment available in the bridge-tailpiece assembly has been limited to fine tuning, usually less than a range of three pitches where the octave has twelve pitches. With the adjustment screws **94** of each

intonation module **20**, it is possible to obtain macro tuning where the range extends over a full octave creating a means to bring from an untensioned condition of the string to proper playing pitch. With this arrangement, it is possible to eliminate the tuning pegs at the opposite end of the guitar and provide what has been characterized as a "headless" guitar. With the range of displacement of the lever member **84**, by contact between the adjustment screw **94** and the curved surface **96** of the lever member, the range of macro tuning can be finely varied like conventional tuning pegs at the head of an instrument.

Accordingly, the intonation modules provide an increased range of tuning, not previously available, and, in combination with the free-to-vibrate portions **98**, formed by the individual lever-like free-to-vibrate portions, the resonant characteristics of the guitar can be improved to achieve the resonant characteristics of a violin.

In FIGS. **6A–6F**, bridge elements **24A–24F** for each of the individual modules are illustrated. The six strings **6**, each associated with a different one of bridge elements **24** are, starting from the top, E, B, G, D, A and E strings. Though not shown, each of the strings has a different make-up or structure, if a single string is used, the strings have different diameters and, if the strings have a core wire wrapped with a helical wire, the diameter of the strings are different. With different diameters and wire characteristics, the change or elongation of each wire, when it is stretched, is also different. Accordingly, the individual bridge elements **24A–24F** are each shaped differently to accommodate the particular string extending over the bridge element having an enlarged curved surface as compared to the prior art.

Each bridge element **24A–F** has a surface contacted by the string with different large continuously variable radii. First radii extend from the initial second critical point toward the neck of the guitar and the second radii extends from the initial critical point in the opposite direction. The first radius for each of the bridge elements is twice the second radius.

Establishing the radii of the bridge element **24F** as a standard of 1:1, the bridge element **24E** has radii as compared to the bridge element **24F** in the ratio of 1.25:1. In turn, the bridge elements **24D**, **24C**, **24B** and **24A** have radii ratios as compared to the bridge element **24F**, as follows:

2.40:1, 1.20:1, 2.46:1 and 4.01:1.

As a result, when the fulcrum tremolo or the bridge-tailpiece assembly is pivoted, the tuned characteristics of the strings relative to one another remain the same.

In FIGS. **6G** and **6H** the prior art arrangement is shown, while FIGS. **6I** and **6J** illustrate the present invention. FIGS. **6G** and **6I** display the initial position of the second critical point, and FIGS. **6H** and **6J** exhibit a pivoted position. The fulcrum pivot point is shown to the left of the bridge element by a dot within a circle. In FIG. **6H** the fulcrum tremolo is pivoted to increase string tension and the second critical point and string height drop. The second critical point moves away from the first critical point.

In FIGS. **6I** and **6J** it can be noted that the bridge element has an enlarged curved surface relative to the bridge element in FIGS. **6G** and **6H**. Further the bridge element surface of the present invention has a continuously varied radius. As set forth in FIG. **6J**, when pivoted the bridge element and the second critical point drop for a lesser amount than in FIG. **6H**, the prior art. Moreover, the second critical point moves over the bridge element surface toward the first critical point. Accordingly, the pivoting effect is augmented and



with continuously variable enlarged curved surfaces corresponding to the stretch characteristics of the strings, it is possible to maintain relative harmonic tuning between the strings.

The continuously varying curved surfaces afford a smooth transition from the sections on opposite sides of the initial second critical point position.

Depending on the strings a single radius can be provided on the opposite sides of the initial second critical point position.

In providing relatively large variable radii for the bridge elements **24A–F**, a previous problem, that develops in pivoting the assembly downwardly toward the neck **4**, where the strings may contact the surface of the neck or fret board **8**, causing the strings to lose their tuned characteristics, is avoided. A stepped base plate **28** provides means for raising the intonation modules upwardly to match the curved surface of the transverse cross-section of the fret board. Additionally, shims **108**, in combination with the stepped base plate **28**, compensate for differing curvatures of the fret board from instrument to instrument from model to model. The shims **108** each have an elongated slot **110**. The slot permits the shim to be placed between the base plate **28** and the base **82** of the intonation module and to be slid past the downwardly extended block **89** of the base which extends through the opening **78**. By releasing the bolt **89*b***, the shim can be inserted and then secured in place by tightening the bolt.

The stepped base plate **28** is shown with the steps **114** affording increases in height from the outside toward the center of the base plate. If necessary, the combination of the shims **108** and the steps **114** in the base plate **28** can be used to achieve the desired height of the strings above the neck.

When the electric guitar **1** is being played, it may be desirable to prevent any accidental pivotal movement of the tremolo arm. While a variety of different tremolo arm locks or limiters can be used, one embodiment is disclosed in FIGS. **9A** and **7B**. In FIGS. **2**, **7A** and **7B**, a tremolo limiter insert **116** is threaded into the wing element **26**. A limiter pin **118** is inserted into the insert **116**. The limiter pin **118** has a head **120** arranged to contact the guitar body, a shank **122** extending through the insert, and a knob **124** on the opposite end of the shank from the head. A compression spring **125** is located between the end of the head **120** connected to the shank **122** and the upper end of the insert **116** through which the shank passes. A thread **126** is formed on the head in engagement with a corresponding thread **127** on the inner surface of the insert. The lower end of the head as viewed in FIGS. **7A** and **7B** is rounded for providing a limited contact area with the guitar body.

In the position shown in FIG. **7A**, the head is in threaded engagement with the insert so that it remains in position preventing the tremolo arm from pivoting so that the bridge-tailpiece assembly cannot pivot.

If the threaded engagement between the head **120** and the insert **116** is released, as shown in FIG. **7B**, the head is retracted into the insert **116** and the tremolo arm **118** and bridge-tailpiece assembly can be pivoted, as desired. An additional thread **127*a*** is located on the head **120** adjacent its free end for holding it in the retracted position, shown in FIG. **7B**.

The spring **125** biases the limiter pin **118** toward the body **3** of the guitar.

In addition to the means for varying the resonance or pitch afforded by the lever-like members of the intonation modules and the wing elements, a set screw, not shown, can be inserted into the free end of the lever member **84**. By varying

the depth or position of these set screws within the wing elements and the lever members, a fine tuning of the pitch of the element or member can be achieved.

In guitars with a "bolt-on" neck design, the neck **4** and body **3** of the guitar are secured together, as shown in FIG. **8A**, note the bolts **132** securing the body and neck together. To raise the string height from the instrument body at the bridge-tailpiece assembly, the flat shim **134** of FIG. **8B** or the wedge shim **136** of FIG. **8C** can be used. As a result, a greater area of the movement is afforded the fulcrum tremolo's upward pitch change for the guitar strings is obtainable and provides for a tighter coupling between the neck and the body.

As mentioned above, a properly adjusted free-to-vibrate portion can be used in a variety of ways to control vibration in different apparatus.

In FIG. **9A**, an engine **140** is illustrated with a free-to-vibrate portion **142** tightly coupled to it for equalizing frequency response. The free-to-vibrate portion has holes **142a** drilled into it to provide the desired resonant character for preventing the development of vibration which would tend to deteriorate the quality of the sound provided by the microphone or speaker.

FIG. **9B** shows a building frame **240A** with a free-to-vibrate portion **242** tightly coupled to it. The free-to-vibrate portion **242** is connected to a part of the structural frame, such as a beam or column.

The free-to-vibrate portion, as shown in FIGS. **9A–C**, could be used in a variety of different mechanisms or vehicles to prevent the development of undesired vibrations. For instance, the free-to-vibrate portions or tines could be connected to the frame of a helicopter or airplane to control vibration. Such free-to-vibrate portions could be used in bridge structures to control harmonic vibrations. Moreover, the free-to-vibrate portions or tines could be employed in combustion engines, electric motors, plumbing, elevator structures, cam shafts, and other structures subject to harmful vibrations.

The foregoing description has been directed to an electric guitar, however, the basic concept described above with regard to vibration or resonance control can also be achieved in an acoustic guitar.

In FIG. **10A**, an acoustic guitar **150** is shown with a resonance bridge-tailpiece **152**. The guitar has a head **154**, a body **156**, and a neck **158** extending between the body and the head. Strings **160** extend between the head **154** and the bridge **152**.

In FIG. **10B**, a different arrangement of the acoustic guitar is depicted with a resonance bridge, to which the strings are connected, located within the body **156** and with the strings **160** secured to the bridge at anchors **162**. In FIG. **10B**, free-to-vibrate portions of the wing elements **164** are located laterally outwardly from the strings **160**. The portions **164** are shaped or drilled to provide the desired resonance effect, note the holes shown toward the free ends of portions **164**. Other free-to-vibrate portions **180** are aligned with the strings **160**.

In FIG. **10C** an electric bass guitar **150A** is illustrated with four strings **160A**. It includes a resonance plate **166** coupled to but separate from an existing bridge-tailpiece **168**. The existing bridge-tailpiece **168** fits onto the base **170** of the plate **172** with free-to-vibrate portions **174** located laterally outwardly from the bridge **168**. An adjustment member with an adjustment screw **176**, a spring steel arm **176a** and a felt pad **176B** is located at a coupled end **178** of each of the groups of three free-to-vibrate portions **174** on the opposite sides of the strings. By adjusting the screw **176**, the spring



steel arm **176a** provides a variably tension pressing the felt pad **176b** against the free-to-vibrate portions **174** for controlling the degree of vibration, whereby the desired resonance of the free-to-vibrate sections **174** can be achieved. This arrangement provides a mute assembly for the free-to-vibrate portion of the resonance plate.

In FIG. **10B**, a one-piece construction is shown of the acoustic guitar bridge-tailpiece with a resonance plate **166A**. The combined bridge and resonance plate is secured to the body of the guitar. The resonance plate **166A** has two wing elements **164** spaced apart by six differently shaped free-to-vibrate sections **180**. Each of the wing elements **164** and the free-to-vibrate sections **180** are drilled or provided with elongated slots to obtain the desired resonance effect. On the combined bridge and resonance plate, the individual strings are anchored each in alignment with a different one of the free-to-vibrate sections **180**. Each string **160** is secured to a separate anchor **162**.

FIGS. **11A–11D** display a device for tuning or tensioning a string in a stringed musical instrument.

In FIG. **11A**, the end of an instrument neck **204** is shown with six strings **206** all of a different size. The strings pass over a nut **210** and each string is secured by a string tensioning or tuning device **250**. There is a separate device **250** for each of the six strings. Each device **250** is similar.

Each device, as can be noted in FIGS. **11B** and **11C** includes a bracket **252** secured to and projecting from the end of the neck **204**. An L-shaped lever **254** is pivotally connected by a pin **256** to the bracket **252** at the end of the bracket spaced from the neck **204**. The L-shaped lever **254** has a first arm **258** extending generally upwardly from the pivot pin **256** as shown in FIG. **11B**. The other or second arm **260** of the lever extends from the pivot pin **256** toward the end of the neck **204**.

String **206** is secured into a slotted opening **262** in the free end of the first lever arm **258**. A first thumb screw **264** is in threaded engagement with the free end of the first lever arm **258** and secures the string **206** in position. A second thumb screw **264a** is located on the first arm **258** adjacent the first thumb screws **264** and closer to neck **204**. Second thumb **206** and affords a fine tuning of the string after the coarse tuning by the first thumb screws.

Adjacent the end of the second lever arm **260** spaced from the pivot pin **256** is a forceps-like clamp **266**, also shown in greater detail in FIG. **11D**. The clamp includes a first part **268** secured to the second lever arm **260** and a second part **270** secured to and projecting downwardly from the bracket **252**. As can be seen best in FIG. **11D**, the first part **268** of the clamp has a plurality of serially arranged teeth **272** for interlocking with a corresponding tooth **274** on the second part **270**.

In FIG. **11B** the clamp **266** is closed, securing the string in the locked position. By opening the clamp **266**, as shown in FIG. **11C**, the lever **254** can be pivoted about the pin **256** so that the tension in the string **206** is released. With the plurality of teeth **272** on the first part **268** the interengagement of one of the teeth of **272** with the corresponding tooth **274** affords a variable adjustment in the tension acting on the string **206**.

As can be noted in the drawing, the end of the string **206** secured by the first thumb screw **264** is adjacent to the nut **210** so that there is little bending in the string.

The spacing between the teeth **272** is selected so that the difference in tension imparted to the string affords specific pitch changes taking into consideration the stretch characteristics of the string.

While the vibration or resonance control is described above with respect to an electric or an acoustic guitar and to

a microphone or speaker frame, it can be readily appreciated that the use of the basic concept is applicable to a broad range of musical instruments and other apparatus or devices where vibrational control is important for the operation of the musical instrument or of the apparatus or device.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

That which is claimed, is:

1. A fulcrum tremolo for a stringed musical instrument comprising a body and a neck extending outwardly from said body, a plurality of strings extending from said body to said neck, a tailpiece securing one end of each of the strings, means for forming a first critical point for each of said strings on said neck, wherein said fulcrum tremolo comprises a base plate, means for raising and adjusting one of said strings to a pitched string condition from an untensioned condition, said means for raising and adjusting comprising a bridge element forming a second critical point, an elongated member located on the opposite side of said bridge element from the first critical point and disposed in spaced relation to said bridge element, means for varying the spacing between said first and second critical points for changing the harmonic tuning, and said base plate being pivotally mounted about an axis extending transversely of said strings for changing the pitch of all said strings at one time as said base plate is pivoted.

2. The fulcrum tremolo set forth in claim 1, wherein said elongated member has a first end closer to said bridge element and a second end more remote from said bridge element, said elongated member forming a passageway extending from the first end thereof toward the second end, said one string being arranged to extend through said passageway and to be secured to said means for raising and adjusting one of said strings at a point spaced from the first end of said elongated member, wherein said elongated member is pivotally displaceable between a first limiting position and a second limiting position and the first end of said elongated member is in spaced relation from the bridge element in and between said first and second limiting positions.

3. The fulcrum tremolo set forth in claim 2, comprising an elongated displacement means located in said means for raising and adjusting for contacting said elongated member and pivotally displacing said elongated member between said first and second limiting means.

4. The fulcrum tremolo set forth in claim 3, wherein said elongated member has a surface extending in the direction between the first and second ends thereof, and said elongated member displacement means comprises an elongated threaded member operable to contact said surface to pivot said elongated member between the first and second limiting positions.

5. The fulcrum tremolo set forth in claim 1, wherein said means for varying the spacing between said first and second critical points comprises a member for securing said means for raising and adjusting to said base plate for positioning said means for raising and adjusting relative to said first critical point.

6. A fulcrum tremolo for use on a stringed musical instrument comprising a body, a neck extending from said body, and an end on said neck spaced apart from said body, a plurality of strings secured at said end and on a tailpiece on said body, each of said strings has a first critical point on said neck and a second critical point on said body, said tailpiece and said second critical points being pivotal together about an axis, said device comprises a bridge-tailpiece assembly pivotally mounted on said body for simultaneously changing the pitch of all strings, said assembly including means for individually moving the second critical point of each of said stings for changing the distance between the first and second critical points and changing the harmonic tuning thereof, and means for macro-tuning each said string individually by varying the tension without changing the distance between the first and second critical points, said means for macro-tuning being pivotal about said axis.

7. A fulcrum tremolo for a stringed musical instrument having a head engaging the first end of the strings, the tremolo comprising:

a base plate pivotable about a pivot axis;

a string anchor engaging the second end of one of the strings;

a bridge element connected to the base plate, pivotable about the pivot axis, engaging the one string intermediate the string anchor and the head;

a macrotuner connected to the base plate rearward of the bridge so that the macrotuner is pivotable about the pivot axis, the macrotuner being operable to adjust the string from an untensioned pitch to a proper playing pitch, the macrotuner comprising:

an elongated arm extending rearwardly adjacent the bridge element; and

a gripping portion intermediate the bridge and the string anchor for gripping the string.

8. The tremolo of claim 7 wherein the tremolo comprises a ball bearing and the base plate is pivotable about the base plate.

9. A fulcrum tremolo for a stringed musical instrument having a head engaging the first end of the strings, the tremolo comprising:

a base plate pivotable about a pivot axis;

a string anchor engaging the second end of one of the strings;

bridge element connected to the base plate, pivotable about the pivot axis, engaging the one string intermediate the string anchor and the head;

a macrotuner rearward of the bridge, operable to adjust the string from an untensioned pitch to a proper playing pitch, the macrotuner comprising:

a gripping portion intermediate the bridge and the string anchor for gripping the string.

10. The tremolo of claim 9 wherein the macrotuner is connected to the base plate so that the macrotuner is pivotable about the pivot axis.

11. The tremolo of claim 9 wherein the macrotuner comprises an elongated arm extending rearwardly adjacent the bridge element.

12. The tremolo of claim 9 wherein the tremolo comprises a ball bearing and the base plate is pivotable about the base plate.

* * * * *

# EXHIBIT B

US005986191A

# United States Patent [19]

McCabe

[11] **Patent Number: 5,986,191**

[45] **Date of Patent: Nov. 16, 1999**

[54] **TUNING MEANS FOR FULCRUM TREMOLO**

[76] Inventor: **Geoffrey McCabe**, 36 E. 7th St., New York, N.Y. 10003

[21] Appl. No.: **08/734,346**

[22] Filed: **Oct. 21, 1996**

[51] **Int. Cl.**$^{6}$ .................... **G01D 3/00**

[52] **U.S. Cl.** .................... **84/313**

[58] **Field of Search** .................... 84/313

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,419,227 5/1995 Lavineway .................... 84/313

5,522,297 6/1996 Enserink .................... 84/313

*Primary Examiner*—William M. Shoop, Jr.

*Assistant Examiner*—Kim Lockett

*Attorney, Agent, or Firm*—Dann, Dorfman, Herrell & Skillman, P.C.; Stephen H. Eland

[57] **ABSTRACT**

A stringed musical instrument is provided wherein each string has two critical points. A fulcrum tremolo is mounted on the instrument for varying the tension of the strings and the distance between the two critical points. The strings are attached to a plurality of intonation modules mounted on the fulcrum tremolo. Each intonation module is adjustable so that the strings can be adjusted from an untensioned state to a proper playing pitch. A bearing assembly is also included to facilitate pivoting of the fulcrum tremolo.

**32 Claims, 4 Drawing Sheets**

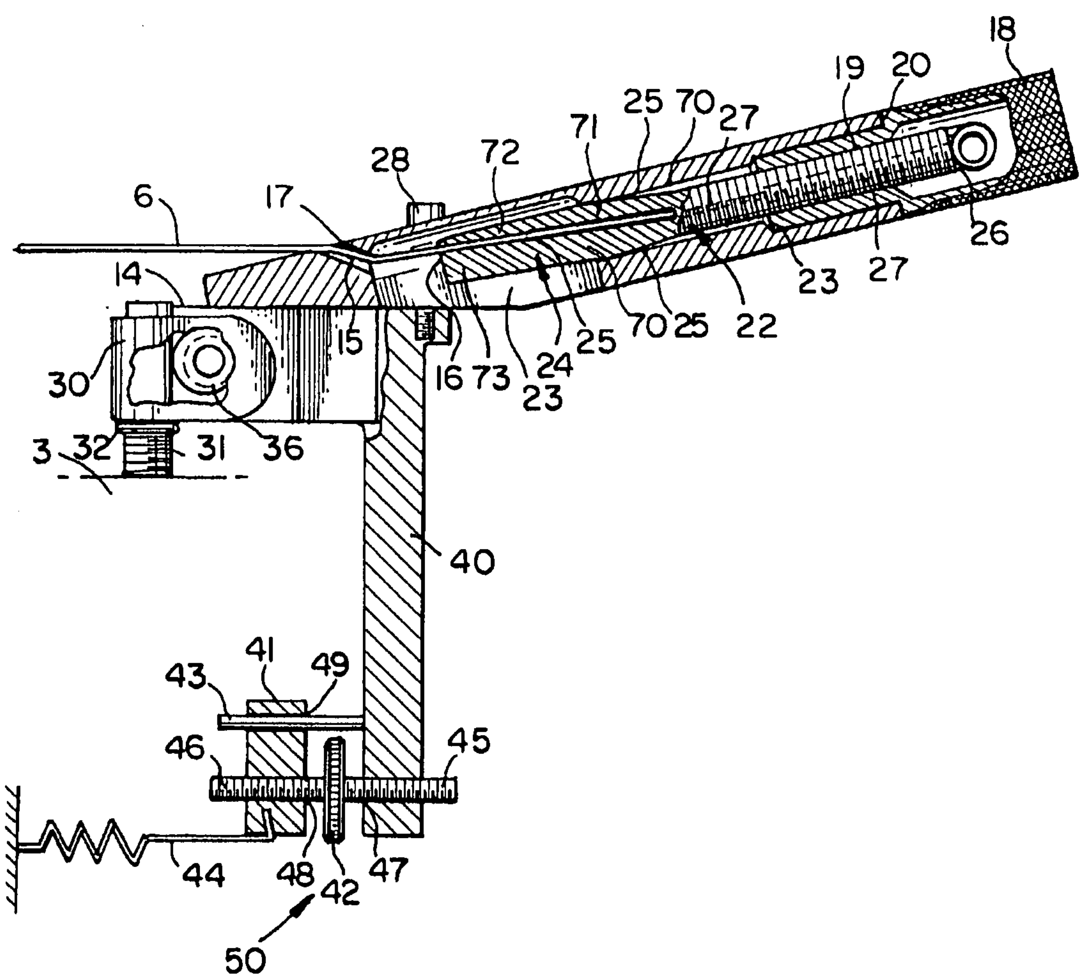


FIG. 1

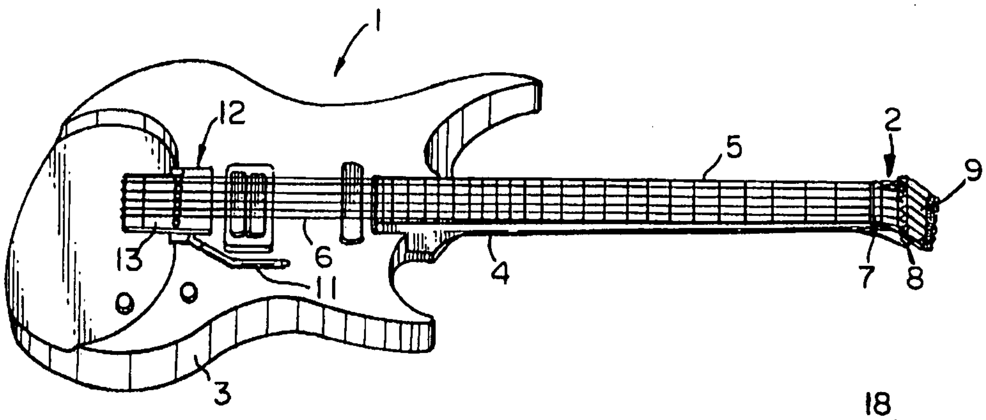

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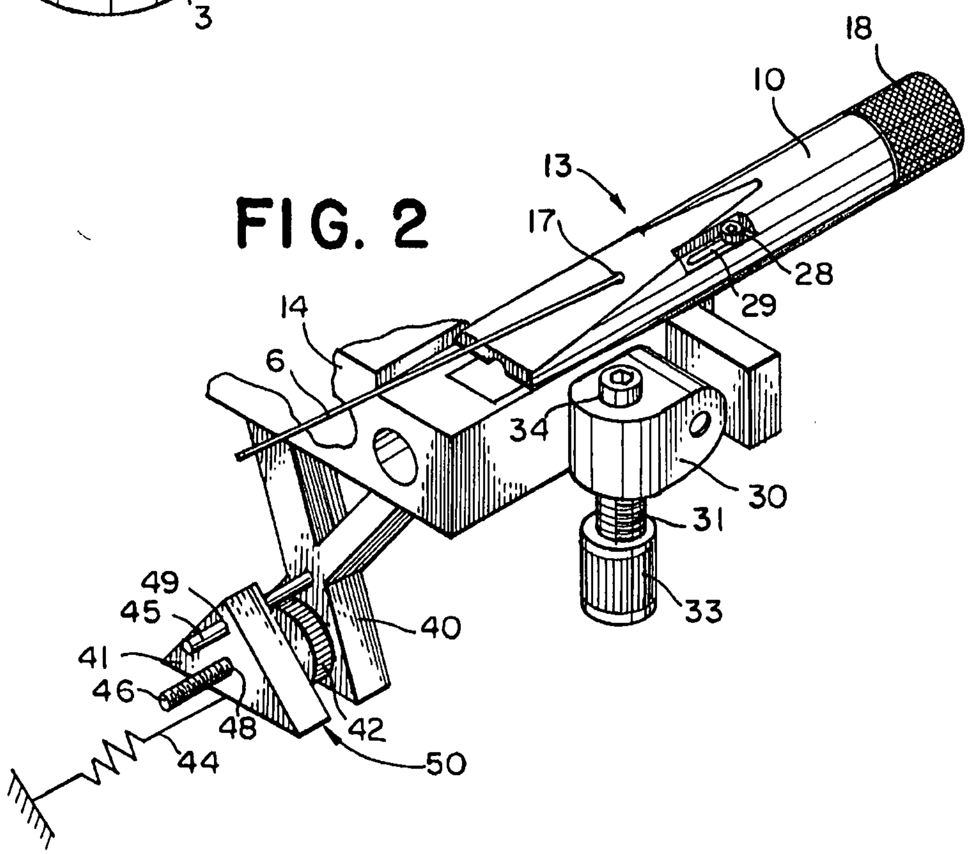
FIG. 2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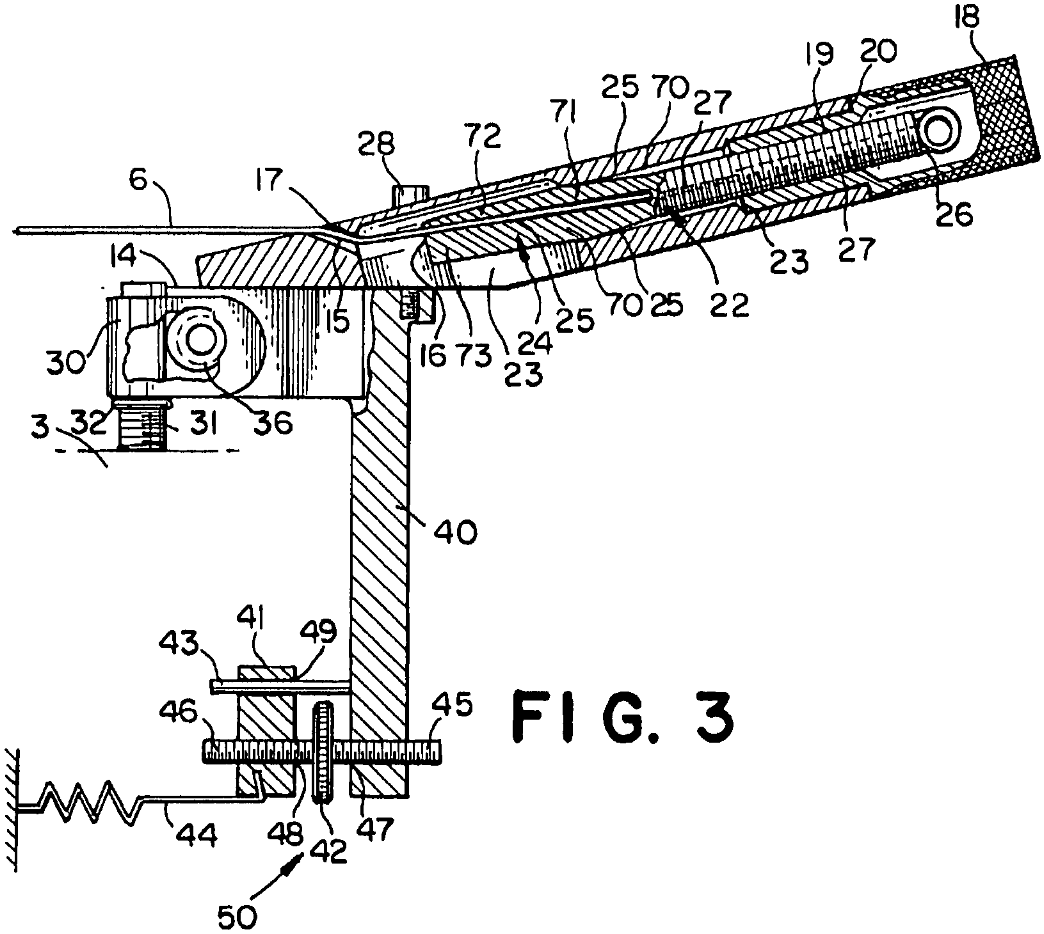

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FIG. 3

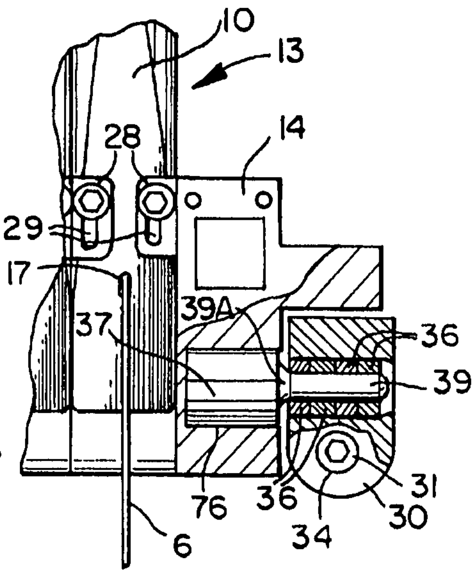

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FIG. 4

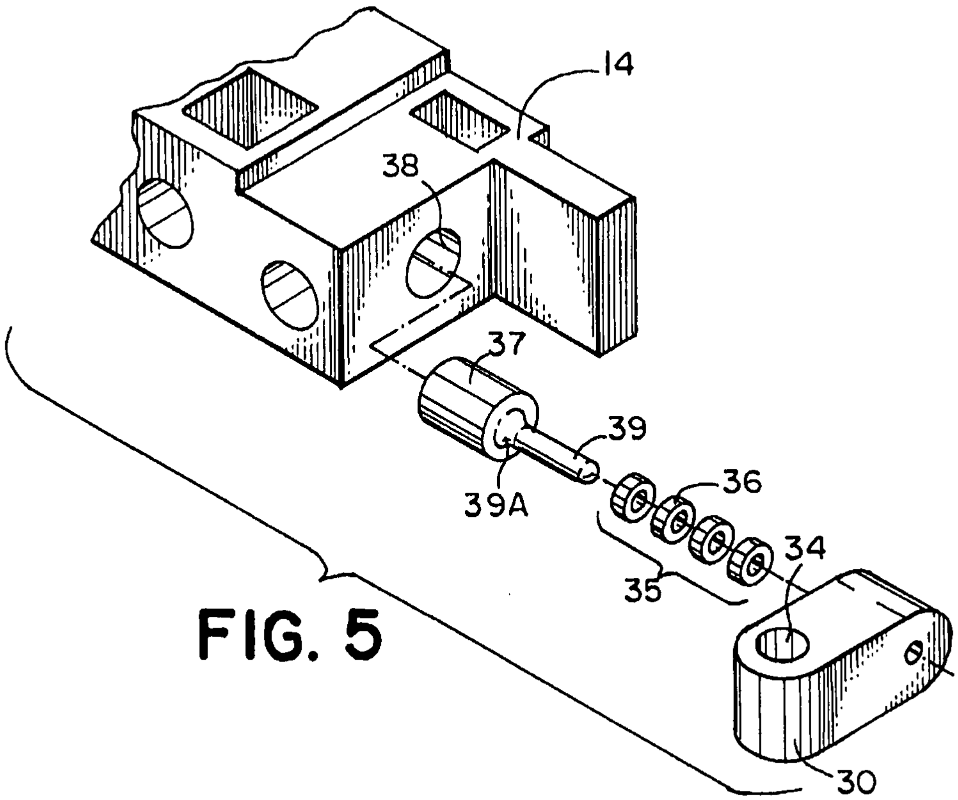


FIG. 5

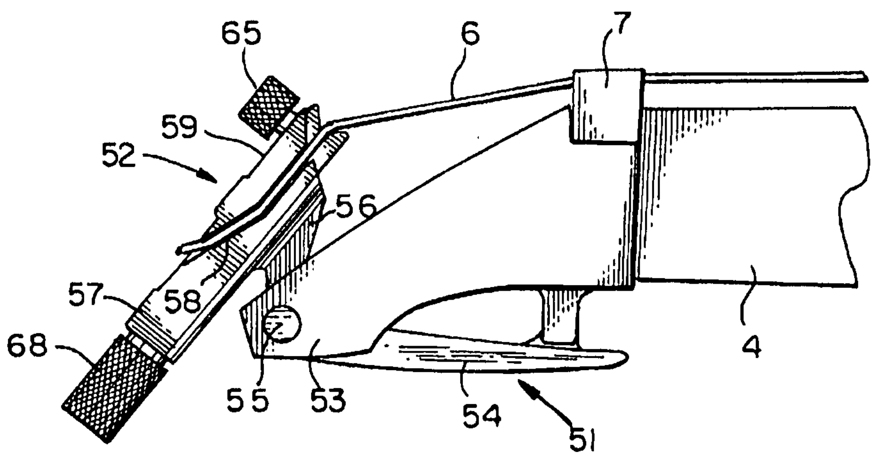


FIG. 6

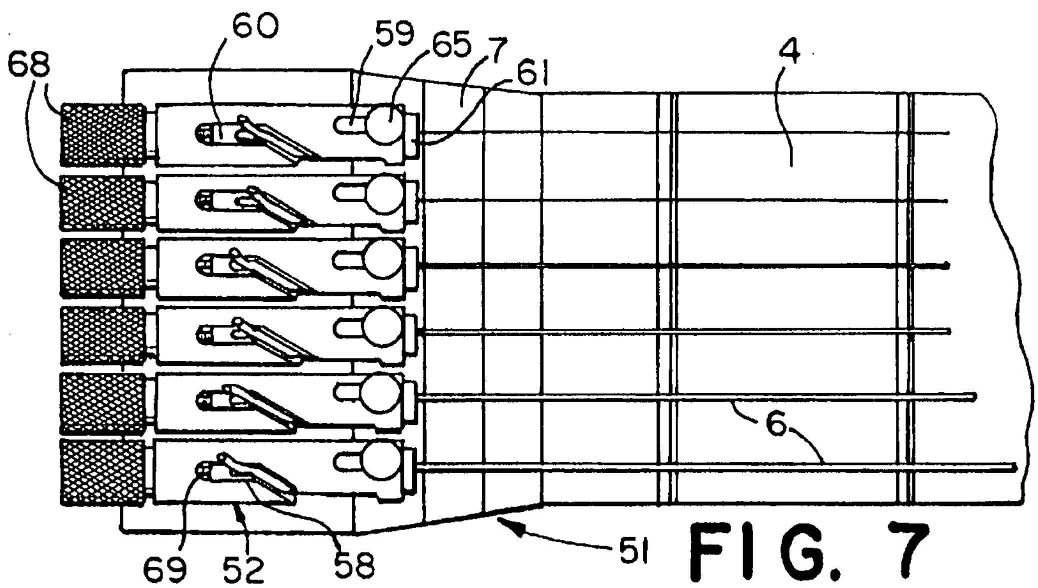
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FIG. 7

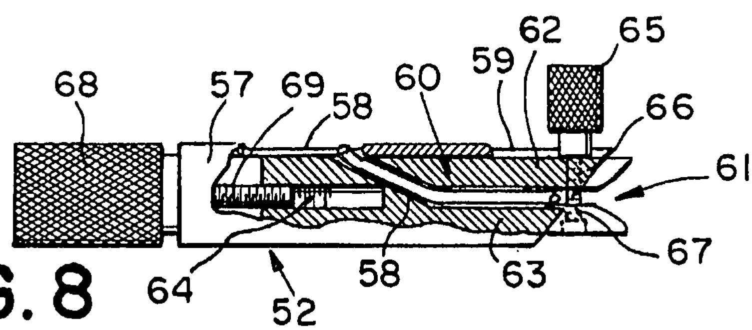
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FIG. 8

# TUNING MEANS FOR FULCRUM TREMOLO

## BACKGROUND OF THE INVENTION

In a stringed musical instrument, such as a guitar, the strings extend unsupported between a first critical point usually formed by the nut where the neck joins the head and a second critical point usually formed by the bridge positioned on the body. The strings are anchored at one end on a portion of the instrument known as the tailpiece, strung over the bridge and the nut on the head of the instrument and in conventional instruments anchored on the other end to the tuning pegs where an untensioned string is tensioned and adjusted to a tuned condition. The second critical point is formed by a part of the bridge or by a part of a combined bridge and tailpiece structure. Traditionally, the size of the bridge elements are quite small so as to create a clearly defined single point of contact between the string and the bridge element. It is between these two points that the string length is determined. This is sometimes referred to as the scale length. Adjusting the relative distance between the first and second critical points is called harmonic tuning. Some bridges structures have individually adjustable bridge elements for each string. Often, the typical construction of the strings, particularly for guitar and bass, has a plain end and a "ball end" where a washer-like addition is wrapped by the string itself as a means to help secure the string to the instrument at the tailpiece. The wrapping usually extends for at least a ½" towards the plain end and as such the tailpiece structure must insure that the wrapping does not extend over the second critical point when arranged on the instrument. Fine tuning has been a long standing problem for stringed musical instruments.

In the Proelsdorfer U.S. Pat. No. 2,304,597, string tensioning devices placed on the tailpiece for fine tuning the pitch of the strings of violins, guitars and the like, were disclosed, however such pitch adjustment is quite limited in range and designed to offer the tuning of the strings a minor adjustment of pitch after the general tuning is achieved with the tuning pegs on the head of the instrument which in part provides the means for raising and adjusting the tension of the strings to pitch from an untensioned condition.

It is known to those skilled in stringed musical instrument design and construction that various tremolos have been proposed and utilized for varying the tension of all the strings simultaneously for the purpose of creating a tremolo sound. Further, it is known to those skilled in the art that there are a great many commonly used names for such devices, such as tremolo, tremolo device, tremolo tailpiece, tremolo bridge, fulcrum tremolo, fulcrum tremolo bridge, fulcrum tremolo tailpiece, fulcrum tremolo bridge-tailpiece, vibrato, vibrato bridge, vibrato tailpiece, vibrato bridge tailpiece, etc.

The forerunner of one such species, known as the fulcrum tremolo, Fender U.S. Pat. No. 2,741,146, shows and provides a tremolo device which incorporates a novel bridge structure which incorporates the tailpiece which is commonly known to provide the anchoring means for the strings. The bridge plate is also known as the base plate. The base plate upon which the individual bridge elements are adjustably secured has a beveled ridge portion mounted to the instrument body by six screws permitting pivotal movement about a fulcrum axis for varying the tension on the strings and producing the desired tremolo effect. Further, the bridge and the tailpiece both move together as the tremolo device is pivoted. A singular aspect of the fulcrum tremolo is that the harmonic tuning is upset as the device is pivoted.



Typically, when a fulcrum tremolo pivots about its fulcrum axis, counter springs are utilized to counteract the pull of the strings. Counter springs are usually connected to the body of the instrument at one end and to an attachment means on the bottom of the tremolo at the other end. One of the most troublesome problems with prior art has been maintaining the initial tuning at proper playing pitch. When a musician plays on the string there is usually some kind of string stretch over time and, consequently, a lessening of tension that results in the overall tuning going out of balance. Similarly, the use of the tremolo itself may also introduce string stretch. Further, various factors such as the changes in the humidity of the atmosphere causing the wood in the neck and/or body of the instrument to swell often create subtle distortions in the instrument's geometry which would then in turn disturb the equilibrium point between the tension of the strings and the tension of the counter springs and then as a consequence disturb the initial position. Initial position refers to a specific equilibrium point between the tension of the strings and the tension of the counter springs at the intended tuned pitched condition of the strings. Often the pivot means is subject to wear and the tremolo does not always return to its initial position.

Improvements to the Fender U.S. Pat. No. 2,741,146 fulcrum tremolo have included using string clamps at the nut and immediately behind the intonation points on each of the bridge elements to limit string stretch to within these two points that define the scale length and separately adopting a novel beveled edge adjustably supported by two screw-like members positioned in the body at the fulcrum point to improve the return to initial position after pivoting the tremolo device (Rose U.S. Pat. No. 4,171,661). In Rose U.S. Pat. No. 4,497,236 a combination of the bridge element, the tailpiece and fine tuners replaced the "novel bridge structure" incorporating the tailpiece of the Fender device so that within the limited range (typically less than a whole tone) the strings could be re-tuned without unlocking the string clamps at the nut. However, string stretch beyond the range of the fine tuners necessitated a correction that is tedious, and time consuming involving unlocking the string clamps, re-tuning the strings, readjusting the clamp, and re-tuning all the other strings to re-balance the equilibrium point back to initial position.

Therefore, for stringed musical instruments, as is known to those skilled in the art:

- the second critical point is a clearly defined point on the bridge or individual bridge elements, the adjustment of which relative to the first critical point on the nut defines the length of the string or scale length and is called harmonic tuning;

for fulcrum tremolos as originated by Fender U.S. Pat. No. 2,741,146, when pivoted:

- both the bridge portions and the string anchoring means, the tailpiece, simultaneously move about a fulcrum axis;
- there is a tendency for the harmonic tuning to be upset; and
- various factors can disturb the equilibrium point between the tension of the strings and the tension of the counter springs and as a consequence disturb the initial position; and

for those fulcrum tremolos equipped with fine tuners as with Rose U.S. Pat. No. 4,497,236, Storey U.S. Pat. No. 4,472,750 and Fender U.S. Pat. No. 4,724,737:

- the fine tuners simultaneously move with the bridge and tailpiece portions about the fulcrum axis when the device is pivoted; and

fine tuners are designed to offer the tuning of the strings a minor adjustment of pitch after the general tuning is first achieved by the tuning pegs on the head of the instrument; and

for those fulcrum tremolos fitted with string locks at the first and second critical points as in Rose U.S. Pat. No. 4,171, 661,

string stretch beyond the clamps at the first and second critical points is eliminated offering the most stability of tuning possible in regards to this set of problems associated with string stretch.

In Steinberger U.S. Pat. No. Re. 31,722 stringed musical instruments without tuning pegs placed in the typical fashion on the head of the instrument were commonly known as "headless" stringed musical instruments. The replacement tuning machines were mounted on the body opposite the side where the neck joins the body.

Takabayashi U.S. Pat. No. 4,608,905 describes an improvement on fulcrum tremolos incorporating, "octave tuners", tuners which function like the tuning pegs at the head of the instrument but which is integrated into the tailpiece function in the tremolo means. The bridge portion of the device comprised a "roller" configuration for the second critical point similar to Storey U.S. Pat. No. 4,742, 750 and Steinberger U.S. Pat. No. 4,704,936. A cylindrical portion adjustably secured to the base plate houses a string holder member for one end of the string which is "fitted in such a manner as to be allowed to move freely in the axial direction". The ball end of each string is arranged to be anchored "to the rear end opening of the string holding members" which is adjustably positionable "in the stretching direction of the strings for effecting octave tuning". The string continues through the string holder member which is sufficient in size to ensure that the wrapping of the ball end does not extend over the second critical point; the string then passes over the bridge element towards the nut. In this device the string holder member accomplishes the tailpiece function by anchoring the string at a single point which moves accordingly when the string holder member is displaced to achieve the tuning of the instrument.

Further improvements in the fulcrum tremolo utilized an arrangement with ball bearings at the pivot point within a housing adjustably mounted to the body which not only improved return to initial position after use of the tremolo but also virtually eliminated the wear and tear associated with prior art (McCabe U.S. patent application Ser. No. 07/607,458, Continuation Ser. No. 08/027,729, filed Jan. 14, 1993).

Additionally, the replacement of fine tuners with macro-tuners on a fulcrum tremolo (McCabe U.S. patent application Ser. No. 07/607,458, Continuation Ser. No. 08/027,729, filed Jan. 14, 1993) provided an intonation module that included a novel integrated one piece bridge-tailpiece structure secured to the base plate where each string anchored within its respective structure passes through a separate lever member and over the bridge element wherein the lever member could be displaced by an adjustment bolt to provide the means to bring and adjust the strings to playing pitch from an untensioned condition circumventing the retuning limits imposed by the fine tuner arrangements. These macro-tuners are often part of an intonation module dedicated to each string for use with but not exclusive to "headless" stringed musical instruments, that is, instruments without tuning pegs placed in the typical fashion on the head of the instrument. Certainly, a fulcrum tremolo with macro-tuners could be used with instruments which had tuning pegs without a disadvantage. Further, macro-tuners could be placed on the head or the body of the instrument and if integrated with a string anchoring means could replace the tuning pegs.



Macro-tuners refer to tuners with the capacity to raise and adjust the tension of the strings from an untensioned condition to a proper playing pitch, and as such provide for alternate tunings and compensation for substantial string stretch during the life of the string essentially without additional means.

Often the musician is called upon to play in an ensemble where the other instruments are not tuned to a typical concert pitch. Accordingly, the musician must flatten or sharpen the initial tuning of all the strings on his instrument in order to meet the pitch requirements of other instruments. This retuning often disturbs the initial position because the tension of the counter springs has not been readjusted as well. Accordingly, the position of the base plate of the tremolo is either tilting away from or towards the body of the instrument which then can limit the range in which the tremolo can be activated. Steinberger U.S. Pat. No. 4,632,005 and Gunn U.S. Pat. No. 4,955,275 provide for an adjustable counter spring and utilize an adjustment knob that provides a means to vary tension of the counter spring and thereby maintain the equilibrium point between the tension of the counter spring and the tension of the strings on fulcrum tailpiece tremolo, that is, a tremolo device where the bridge elements do not pivot with the anchoring means and, therefore, do not upset the harmonic tuning as such. There is no prior art for this type of arrangement on a fulcrum tremolo.

An alternate means to tuning pegs on the head of the instrument has been proposed in a quick tuner arrangement design (McCabe U.S. patent application Ser. No. 07/607, 458) wherein the tuning device, now known to those skilled in the art as a "semi-headless tuner", has the capacity to individually anchor and bring the strings to playing pitch and then accomplishing the fine tuning. The primary tuning means is afforded by a forceps-like clamp at one end of a L-shaped arm with a plurality of "teeth" engaged with "teeth" on a holding bracket. This arrangement provides for a variety of locking positions that correspond to a variety of pre-set tuned conditions for the associated strings secured to the opposite end of the L-shaped arm. The secondary tuning means or fine tuning is provided by a small thumb screw adjacent the point where the string is secured to the L-shaped arm, however, this arrangement is subject to premature string breakage and a limited range.

Additionally, these improvements listed above are characterized by a number of other defects or limitations which will now be briefly indicated. The ball bearing means (McCabe U.S. patent application Ser. No. 07/607,458, Continuation Ser. No. 08/027,729, filed Jan. 14, 1993) for adjustably mounting the fulcrum tremolo to the instrument body are arranged in a bearing housing supported within a fork-like structure in the base plate. This placement of the bearing arrangement is often then too close to the pickups and prevents installation on some instruments. Further, for instruments being built to receive this design, the typical placement of the pick-up in relation to the second critical point is disturbed and may affect the tonal character of the instrument in an undesirable manner. Further, the fork-like portion that holds each bearing housing is delicate and is subject to breakage.

The design of the macro-tuners (McCabe U.S. patent application No. 07/607,458, Continuation Ser. No. 08/027, 729, filed Jan. 14, 1993) requires the string to be bent severely to achieve the necessary tuning. This arrangement

makes tuning at the higher pitches difficult and in some cases may introduce string breakage.

The "octave tuners" of the Takabayashi fulcrum tremolo U.S. Pat. No. 4,608,905 anchor the strings at a point on the string holder member spaced on the opposite side from the second critical point on the bridge elements. This arrangement presents serious problems:

- the length of the string subject to stretch beyond scale length, which includes the additional string length as measured from the bridge element to the anchoring point, is excessive in general practice at initial position and is far more so when the device is pivoted as would be seen in view of the improvements made by Rose U.S. Pat. No. 4,171,661 and,
- the tensioning of the strings which holds the ball end of the string securely against the outer opening of the string holding member is inadequate to keep the ball ends as seated throughout the performance range of the tremolo; such mis-seatings are devasting to the effort to maintain a tuned fulcrum tremolo.

## SUMMARY OF THE INVENTION

Accordingly, the primary object of this invention is to provide improvements in the mounting means of the bearing and bearing housing arrangement for pivotally supporting the base plate of the fulcrum tremolo that will allow a greater range of installation possibilities.

It is a further object of the invention to provide the intonation modules with macro-tuners integrated with a string anchoring means, known to those skilled in the art as a tailpiece. The intonation modules each include a separate string tensioning element that functions to secure the string adjustably to the fulcrum tremolo. This string tensioning element is in threaded engagement with an adjustment bolt for positioning relative to the second critical point for accomplishing the macro-tuning. The string tensioning element includes a fork-like string clamping means in bearing contact with a restricted portion within the a sleeve-like portion of the intonation module structure that remains stable through the full range of the tremolo and secures the string as close as possible to the second critical point in order to limit the length of string that would otherwise be subject to stretch. By threading the adjustment bolt, the string tensioning element is displaced simultaneously:

- increasing the tension of the associated string to a proper pitched condition and varying the tension of the string thereof so as to provide the macro-tuning function, and
- drawing the fork-like string clamping means of the string tensioning element within the restricted portion of a sleeve-like portion of the intonation module structure, compressing and closing the forks upon the string at the clamping point for transferring the anchoring of the string to an improved anchoring means positioned at the end of the string tensioning element closest to the second critical point.

Yet, another object of the invention is to provide a global tuning mechanism on the fulcrum tremolo which would compensate for the problems associated with varying humidity on the instrument as well as other factors that could affect the instrument's geometry. Further, a global tuner would also provide a simple and quick means for the musician to adjust the initial position in order to meet the pitch requirements in varied situations. Further, the global tuner in reestablishing the initial position allows the full range of pivoting the tremolo in either direction. Global tuners refer to a means on a fulcrum tremolo with the



capacity to adjust the equilibrium point between tension of the counter spring(s) and the tension of the strings in order to compensate for changes in tension on the strings or the counter springs. The global tuner employs a thumb screw-like means with an additional reverse-threaded shaft on the opposite side of the thumb wheel; one side one of the two shafts is threadedly engaged with the spring attachment means on the tremolo and the other of the two shafts is similarly engaged with a separate counter spring holder. The counter springs are attached to the body as in prior art on one end and to the separate spring holder on the other. When the thumb screw is threaded the relative distance between the spring attachment means on the base plate of the tremolo and the attachment point of the springs to the body can be adjusted, thereby varying the tension of the counter springs in order to compensate for the variations in tension of the strings associated with redefining or reestablishing the initial position.

Another object of the invention is to replace the fine tuner portion on each of the L-shaped arms of the "semi-headless tuners" with an additional macro-tuner mechanism and, therefore, provide for greater range and easier use. This advancement for adjustably securing each string to a improved clamping means positioned within a sleeve-like portion on one end of a L-shaped arm provides the capacity to tune the string from an tensioned condition to pitched string condition. As in prior art each L-shaped arm can pivot and be selectively positioned to a number of pre-set positions relative to the nut or first critical point for raising from an untensioned to a pre-set pitched string condition. A variant of this arrangement eliminates the L-shaped arm and positions a plurality of macro-tuners integrated with a string anchoring means at the nut wherein the clamping means is positioned at the first critical point to eliminate string length that would be otherwise subject to stretch as compared to those found in conventional tuning peg arrangements.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had by the accompanying drawings and descriptive matter in which there are illustrations and described preferred embodiments of the invention.

## BACKGROUND OF THE INVENTION

In the drawings:

FIG. **1** is a plan view of an electric guitar embodying the present invention.

FIG. **2** is a perspective view of the macro-tuners, bearing mounting arrangement and global tuner of the present invention as used in the electric guitar.

FIG. **3** is a side view cross-section of the tremolo mechanism showing the macro tuners, bearing mounting arrangement and the global tuner.

FIG. **4** is a top view cross-section of the ball bearings, the housing mounting means.

FIG. **5** is an exploded perspective view of the bearing ball bearings, the housing mounting means.

FIG. **6** is a side view of the "semi-headless tuners" with two macro-tuning means.

FIG. **7** is a top view of the "semi-headless tuners" arranged on the neck of the guitar adjacent the nut.

FIG. **8** is a cross-section view of the side of a macro-tuning mechanism.

## DETAILED DESCRIPTION OF THE INVENTION

In FIG. 1, an electric guitar 1 is illustrated comprising a head 2 at one end, a body 3 at the other end, with a neck 4 extending between the head and the body. Six strings 6 extend from head 2 to body 3 over neck 4. Neck 4 forms fret board 5 for guitar 1. At head 2, each of the strings extends over nut 7 forming the first critical point for the strings. Nut 7 is located at the transition of neck 4 to head 2. Each string 6 is secured on the head by anchor 8 and each anchor has a corresponding tuner 9. On the body 3, strings 6 are secured to fulcrum tremolo 12. Fulcrum tremolo 12 has arm 11 for pivoting the tremolo and providing the vibrato effect on the strings. Fulcrum tremolo 12 has six intonation modules 13. The intonation modules present improvements to the macro-tuning invention which incorporates the function of the bridge element and tail-piece in its structure as well as the capacity to adjustably secure the individual strings to the instrument. The intonation modules are movable and thereby provide a means to change the distance between the first and second critical points or the harmonic tuning as such.

The invention is shown for us on electric guitar 1 and it should be understood that the invention could be used on a variety of stringed musical instruments.

In body 3 of guitar 1 there are electric pickups.

In the following description, fulcrum tremolo 12 will be described in greater detail.

Fulcrum tremolo 12 forms a second critical point for strings 6, sometimes characterized as an intonation point or bridge point.

In FIG. 2, fulcrum tremolo 12 is shown on an enlarged scale compared to FIG. 1. FIG. 3 displays fulcrum tremolo 12 of FIG. 2 in a cross-section view. The second critical point is located near the front intonation modules 13. Outwardly from intonation modules 13 on each side of the opposite sides of base plate 14 extending in the direction of the strings there are bearing housings 30. The bearing housing 30 supports base plate 14 pivotally relative to body 3. Global tuner 50 is positioned between spring block 40 extending downwardly from the bottom of base plate 14 and counter springs 44 connected to instrument body 3.

In FIGS. 2 and 3, one of the intonation modules 13 is shown including a shaped barrel-like base 10 with a second critical point formed at string opening 17. Base 10 is adjustably secured to base plate 14 of fulcrum tremolo 12 by machine screws 28 through slots 29. Loosing machine screws 28 permits longitudinal movement of base 10 and associated parts for harmonic tuning of string 6. Adjustment bolt 18 first passes through opening 20 in base 10 and threaded portion 19 of adjustment bolt 18 is engaged with threaded portion 21 of string tensioning element 22 within sleeve-like portion 23 of base 10. String 6 of the musical instrument makes critical contact with base 10 at the string opening 17 to passageway 15 sloping downwardly and rearwardly through base 10 until the string passes into a sleeve-like portion 23. String 6 continues passing through clamping point 16 of string tensioning element 22, through slots 25 between upper fork 72 and lower fork 73 of fork-like string clamping means 24, through string passageway 27 of string tensioning element 22 and is secured at exit 26. Annular flange-like portion 71 of fork-like string clamping means 24 of string tensioning element 22 is in bearing contact with restricted portion 70 of sleeve-like portion 23 of base 10. Threading adjustment bolt 18 displaces the string tensioning element 22 relative to string opening 17 providing an adjustment whereby tension or pull on string 6 is applied and varied for raising and adjusting the strings 6 from an untensioned condition to a pitched string condition; simultaneously, annular flange-like portion 71 of fork-like string clamping means 24 of string tensioning element 22 is drawn within restricted portion 70 of sleeve-like portion 23, clamping string 6 between upper fork 72 and lower fork 73 at clamping point 16 adjacent to string opening 17.



In FIGS. 2, 3, 4 and 5 outwardly from intonation modules 13 on each side of the opposite sides of base plate 14 shown at the forward end of fulcrum tremolo 12 extending in the direction of the strings, there is bearing housing 30. Bearing housing 30 is adjacent to base plate 14. Housing 30 is adjustably supported relative to body 3 of the instrument by threaded post 31 with annular flange 32. Post 31 is threaded into insert 33 in body 3. By threading post 31 into insert 33, the spacing between body 3 and housing 30 is selectively adjustable. Adjustment of post 31 is effected through an oval opening 34 in the top of housing 30. In housing 30 rearward post 31, there is opening 76 extending transversely of the string direction of guitar1 containing bearing assembly 35, formed by four side-by-side roller bearings 36. Insert 37 fits into cut-out 38 in the side of base plate 14 with pin 39 with annular flange 39a extending outwardly through bearings 36. Annular flange 39a on pin 39 spaces the side-by-side roller bearings 36 from base plate 14. Accordingly, by manipulating tremolo arm 11, fulcrum tremolo 12 can be pivoted about pin 39 to achieve the desired tremolo effect.

As can be seen in FIGS. 2 and 3 there is spring attachment means 40 extending downwardly from base plate 14. The preferred embodiment incorporates thumb screw 42 with shaft 45 threadedly engaged with threaded opening 47 in spring block 40 on one side of thumb screw 42 and another shaft 46 with reverse threads in the opposite direction of shaft 45 threadedly engaged with reverse threaded opening 48 in spring holder 41. Counter springs 44 are attached at one end to spring holder 41 and to body 3 on the other end of counter springs 44. Guide pin 43 extending outwardly from spring block 40 towards spring holder 41 passes through guide pin opening 49 in spring holder 41 limiting longitudinal rotational movement of spring holder 41 relative to spring block 40. By threading thumb screw 42 clockwise relative to spring holder means 41, spring holder 41 moves closer to spring block 40 increasing the tension of the counter springs 44 and by threading thumb screw 42 counter-clockwise relative to spring holder means 41, spring holder 41 moves away from spring block 40 decreasing the tension of the counter springs 44 providing the means to adjust the equilibrium point and globally tune fulcrum tremolo 12.

FIG. 6 displays an improved "semi-headless" tuner arrangement for stringed musical instruments.

In FIG. 7, at the end of 4 is shown with strings 6 each of a different size. The strings 6 pass over nut 7 and each string is secured by string tensioning tuning device 51, a "semi-headless tuner" adjacent the nut. There is a separate macro-tuning device 52 for each string.

The devices, as set forth in FIGS. 6 & 7 includes bracket 53 secured to and projecting from the end of neck 4. L-shaped lever 54 is pivotally connected by pin 55 as shown in FIG. 6. The other or second arm 56 of lever 54 extends from pivot pin 44 toward the end of neck 4.

At the end of second arm 56 there is sleeve-like portion 57. String slot 58 extends longitudinally along sleeve-like portion 57 continuing disposed at an angle towards the top of the sleeve. Slot 59 at the free end of the sleeve extends towards the connected end of second arm 56.

Adjacent the free end and within sleeve-like portion **57**, there is string clamping means **60** with fork-like portion **61** with upper fork **62** and lower fork **63** and at the opposite end there is threaded opening **64**. Thumb screw **65** passes through slot **59** in sleeve-like portion **57** and through unthreaded opening **66** in upper fork **62** and is threadedly engaged with threaded opening **67** in lower fork **63**. String **6** is arranged through slotted opening **58** and into slotted opening **75** between upper fork **62** and lower fork **63**. Threading thumb screw **65** clamps the upper fork **62** and lower fork **63** on string **6**, securing string **6** to string clamping means **60**.

Adjustment bolt **68** is adjustably mounted within sleeve-like portion **57** opposite the free end. Threaded portion **69** of adjustment bolt **68** is threadedly engaged with threaded opening **64** adjustably securing string clamping means **60** to macro-tuner **52**. By threading adjustment bolt **68** the clamping means can be displaced relative to nut **7** wherein the tension on string **6** can be raised and varied whereby the macro tuning can be achieved.

In FIG. **8**, shows a single macro-tuning device where string **6** passes through slots **58** of sleeve-like portion **57** and is arranged between upper fork **62** and lower fork **63** of fork-like portion **61** of string clamping means **60** and clamped and secured by thumb screw **65** wherein threaded portion **69** of adjustment bolt **68** is threadedly engaged with threaded opening **64** of string clamping means **60**. By threading adjustment bolt **68** the position of string clamping means **60** relative to the anchoring means at the opposite end string **6** is increased and varied whereby tension or pull on string **6** is applied and varied for raising and adjusting the strings **6** from an untensioned condition to a pitched string condition.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

I claim:

1. Tuning apparatus for a stringed musical instrument comprising a body and a neck extending outwardly from said body, a plurality of strings extending from said body to said neck, means for forming a first critical point for each of said strings on said neck, means for forming a second critical point for each of said strings on a fulcrum tremolo, said fulcrum tremolo includes a base plate, said base plate being pivotally mounted about a fulcrum axis extending transversely of said strings for changing the pitch of all said strings at one time as said base plate is pivoted, separate means for mounting each of said strings on said base plate and for raising and adjusting the tension of said strings from an untensioned condition to a proper playing pitch including means for varying the spacing between said first and second critical points for changing the harmonic tuning, wherein the improvement comprises that each of said separate means for mounting each of said strings has a bridge element forming said second critical point and a string tensioning means on opposite side of said bridge element from said first critical point disposed in a variably spaced relation to said second critical point over which each of said string extends.

2. Apparatus as set forth in claim **1** wherein said separate means has a sleeve-like member, said sleeve-like member has a first portion closer to said second critical point and a second portion more remote from said second critical point, said sleeve-like member includes a restricted interior portion between said first and second ends thereof, said string tensioning means has a first end closer to said bridge element and a second end more remote from said bridge element, said string tensioning means is displaceable between a first limiting position and a second limiting position and the first end of said string tensioning means is in spaced relation from said bridge element in and between said first and second limiting positions.

3. Apparatus as set forth in claim **2** wherein string tensioning means has a string passageway extending from the first end thereof toward the second end, said string arranged to extend through said string passageway and secured to said string tensioning means at said second end.

4. Apparatus as set forth in claim **3** wherein said string tensioning means has a threaded portion extending in the direction of the first end from said second end of said string tensioning means, said string tensioning means has a string clamping means extending from said first end of said string tensioning means towards said threaded portion, and said string tensioning displacement means comprising an bolt-like member adjustably mounted in said separate means and arranged to threadedly engage said string tensioning means for displacing said string tensioning means between said first and second limiting positions.

5. Apparatus as set forth in claim **4** wherein said string clamping means has a fork-like slotted string passageway extending from said threaded portion to said first end of said string tensioning means, said string clamping means including a clamping point at first end of said string tensioning means, said fork-like slotted string passageway has a lower fork closer to said base plate and an upper fork more remote from said base plate, said string clamping means has a annular flange-like portion in bearing contact with said restricted interior portion of said sleeve-like member, said string arranged to extend through said string passageway between said upper and lower forks, wherein as said string tensioning means is displaced in and between said first and second limiting positions for macro-tuning said string, said upper and lower forks are simultaneously displaced towards said string within said restricted interior portion for anchoring said string at said clamping point.

6. A stringed musical instrument comprising an elongated neck and body attached to one end of the said neck, a tremolo device mounted on said body, a plurality of elongated strings, means on said neck for supporting and forming a first critical point for each of said strings, said tremolo device forming a support for and second critical point for each of said strings, said tremolo device comprising a fulcrum tremolo, said fulcrum tremolo including bearing means mounted on said body and supporting said fulcrum tremolo for pivotal displacement, said bearing means comprises at least one ball bearing and at least one bearing housing for adjustably positioning said bearing means relative to said body and at least one shaft is connected to said base plate through said ball bearing wherein the improvement comprises an annular flange on said shaft which spaces said bearing means away from said base plate.

7. A stringed musical instrument comprising an elongated neck and body attached to one end of the said neck, a fulcrum tremolo mounted on said body, a plurality of elongated strings, means on said neck for supporting and forming a first critical point for each of said strings, said fulcrum tremolo forming a support for and second critical point for each of said strings, said fulcrum tremolo including counter springs with a first end and a second end, said first end of said counter springs connected to said body and said second end of said counter springs connected to an attachment means on said fulcrum tremolo for counter balancing the tension of said elongated strings wherein the improve-

ment comprises that said attachment means includes a separate means for globally tuning said fulcrum tremolo.

8. Apparatus as set forth in claim 7 wherein said separate means comprises a spring holder means disposed in spaced relation between said first end of said counter springs and said attachment means.

9. Apparatus as set forth in claim 8 wherein said spring holder means is displaceable between a first limiting position and a second limiting position and said spring holder means is in spaced relation from said attachment means in and between said first and second limiting positions.

10. Apparatus as set forth in claim 9 wherein said attachment means has a threaded passageway extending in the direction of said spring holder means, said spring holder means has a threaded passageway extending in the direction of said counter springs and an unthreaded passageway extending in the direction of said attachment means, and said string holder displacement means comprises a thumb screw-like member arranged with a first threaded portion extending in the direction of said counter springs and a second threaded portion extending in the direction of said attachment means.

11. Apparatus as set forth in claim 10 wherein said first threaded portion of said thumb screw-like displacement means is threadedly engaged with said threaded passageway of said spring holder means and said second threaded portion of said thumb screw-like displacement means is threadedly engaged with said threaded passageway of said attachment means for displacing said string holder means in and between said first and second limiting positions.

12. Apparatus as set forth in claim 11 wherein said attachment means has a pin extending in the direction of said spring holder means and said pin passes through said unthreaded opening of said spring holder means for limiting the rotation of said spring holder means about said thumb screw-like displacement means.

13. In a stringed musical instrument, means for locking and tensioning at least one string from an untensioned condition to a tuned pitched condition at one end of the neck of a stringed musical instrument, said means comprising a string locking means for said at least one string, a bracket secured to said one end of said neck, a lever pivotally secured to said bracket, said string locking means secured to said lever, said lever is L-shaped comprising a first lever arm extending angularly from a second lever arm and said lever arms secured together at an intersecting section and a pivot pin extending through said intersecting section and said bracket for pivoting and securing said lever to said bracket, a locking clamp for adjustably securing said second lever arm to said bracket, said first lever arm has a free end spaced from said intersecting section, wherein the improvement comprises that said first lever arm includes an string holder means for securing and macro-tuning said at least one string.

14. A tuning apparatus for a stringed musical instrument, a plurality of strings extending over said stringed musical instrument, each of said strings having a first end and a second end, each of said first end of said strings having a first anchoring means on a first section of said stringed musical instrument and each of said strings having a second anchoring means on a second section of said stringed musical instrument, separate means for raising and adjusting the tension of at least one string from an untensioned condition to a tuned pitched condition, wherein the improvement comprises that said separate means has a string securing means including said first anchoring means for macro-tuning said at least one string.

15. Apparatus as set forth in claim 14, wherein said string securing means has a first end closer to said second anchoring means and a second end further to said second anchoring means, said string securing means is displaceable between a first limiting position and a second limiting position and the first end of said string securing means is in spaced relation from said second anchoring means and in between said first and second limiting positions.



16. Apparatus as set forth in claim 15 wherein each said separate means includes a sleeve-like member with a first section closer to said second anchoring means and a second section closer said second anchoring means, said first end of said string securing means has a string passageway closer to said second anchoring means extending in the direction between said first and second ends thereof, said string securing means has a threaded portion further from said second anchoring means extending in the direction between said first and second ends thereof, and said string securing displacement means comprising an bolt-like member adjustably mounted in said sleeve-like member and arranged to threadedly engage said string securing means for displacing said string securing means in and between said first and second limiting positions.

17. Apparatus as set forth in claim 16, said sleeve-like member has a first slot arranged in said first section thereof, a first side of said sleeve-like member associated with said first slot, said string securing means has a fork-like string passageway extending from said first end thereof towards said second end of said string securing means, said fork-like string passageway means has a upper fork closer to said first slot and an lower fork more remote from said first slot, said upper fork has an unthreaded passageway transverse the direction of said fork-like passageway, said lower fork has a threaded passageway transverse the direction of said fork-like passageway, said upper and lower forks are displaceable between an open position and a closed position.

18. Apparatus as set forth in claim 17, wherein said upper and lower fork displacement means comprising a thumb screw-like member adjustably arranged to pass through said first slot of said sleeve-like member, through said unthreaded passageway of said upper fork and threadedly engage said threaded passageway of said lower fork for displacing said upper and lower forks in and between said open and closed positions towards said string for clamping and securing said at least one string.

19. Apparatus as set forth in claim 18, wherein said sleeve-like member has a second slot extending from said first section of said sleeve-like member towards said second section thereof adjacent said fork-like string passageway and continuing disposed at an angle towards said first side of said sleeve-like member associated with said first slot wherein said at least one string is arranged to extend through said second slot and into said fork-like string passageway between said upper and lower forks.

20. Apparatus as set forth in claim 13 wherein string holder means for securing and macro-tuning said at least one string is said string securing means for macro-tuning said at least one string as set forth in claim 14.

21. Apparatus as set forth in claim 16, wherein said sleeve-like member includes a restricted portion between first and second section thereof, said string securing means has a string passageway extending from the first end thereof toward the second end, said string arranged to extend through said string passageway and secured to said string securing means, said string securing means includes a string clamping means, said string clamping means in and between said first and second ends of said string securing means, said string clamping means has a fork-like slotted string passageway extending from said threaded portion to said first end of

said string securing means, said string clamping means including a clamping point at first end of said string securing means, said fork-like slotted string passageway has a first fork and second fork, said string clamping means has a annular flange-like portion in bearing contact with said restricted portion of said sleeve-like member, said string arranged to extend through said string passageway and between said first and second forks, wherein as said string clamping means is displaced in and between said first and second limiting positions said first and second forks are displaced within said restricted portion of said sleeve-like member for securely clamping said string at said clamping point.

**22**. Apparatus as set forth in claim **18** is part of a tremolo device wherein said first end of said string securing means is adjacent to said second critical point.

**23**. A tremolo operable with a musical instrument having a body and a plurality of strings in a tensioned state connected to the body, the tremolo comprising:

a based mounted to the body, pivotable about a fulcrum axis, wherein the tension in the strings tends to pivot the base in a first direction about the fulcrum axis;

a tremolo arm operable to pivot the base about the fulcrum axis to create a tremolo effect;

a biasing element connected to the body wherein the biasing force of the biasing element tends to pivot the base in a second direction against the tendency of the base to pivot the base in a first direction in response to the tension in the strings; and

an adjustment mechanism disposed between the biasing element and the base, operable to adjust the biasing force of the biasing element.

**24**. The device of claim **23** wherein the base includes an elongated arm and the adjustment mechanism operates to vary the distance between the arm and the biasing element.

**25**. The device of claim **23** comprising a block connected to the biasing element and an elongated arm connected to the base, wherein the adjustment mechanism threadedly engages at least one of the block and the elongated arm.

**26**. The device of claim **24** comprising an alignment element operable to impede rotation of the block in one direction relative to the elongated arm.

**27**. A tremolo operable with a musical instrument having a body and a plurality of strings in a tensioned state, connected to the body, the tremolo comprising:

a based mounted to the body, pivotable about a fulcrum axis, wherein the tension in the strings provide a force in a first direction that tends to pivot the base in a first direction about the fulcrum axis;

a tremolo arm operable to pivot the base about the fulcrum axis to create a tremolo effect;

a counter balance producing a force in a second direction to counter balance the string tension force to establish an equilibrium point of rotation of the base;

an adjustment mechanism operable to adjust the equilibrium point of rotation of the base.

**28**. The device of claim **27** wherein the adjustment mechanism varies the counter balance force.

**29**. The device of claim **27** wherein the base includes an elongated arm and the adjustment mechanism operates to vary the distance between the arm and the counter balance.

**30**. The device of claim **27** comprising a block connected to the biasing arm and an elongated arm connected to the base, wherein the adjustment mechanism threadedly engages at least one of the block and the elongated arm.

**31**. The device of claim **29** comprising an alignment element operable to impede rotation of the block in one direction relative to the elongated arm.

**32**. A tremolo operable with a musical instrument having a body and a plurality of strings in a tensioned state, connected to the body, the tremolo comprising:

a base mounted to the body, pivotable about a fulcrum axis;

a tremolo arm manually operable to pivot the base about the fulcrum axis to produce a tremolo effect;

a tuning element connected with the base operable to simultaneously vary the tension in each of the strings.

* * * * *

EXHIBIT C

# EXHIBIT C

US006175066B1

(12) **United States Patent**
**McCabe**

(10) **Patent No.: US 6,175,066 B1**
(45) **Date of Patent: Jan. 16, 2001**

(54) **TUNING MEANS FOR STRINGED MUSICAL INSTRUMENT**

(76) Inventor: **Geoffrey McCabe**, 36 E. 7th St., New York, NY (US) 10003

( * ) Notice: Under 35 U.S.C. 154(b), the term of this patent shall be extended for 0 days.

(21) Appl. No.: **08/027,729**

(22) Filed: **Jan. 14, 1993**

**Related U.S. Application Data**

(62) Division of application No. 07/607,458, filed on Oct. 31, 1990, now Pat. No. 5,198,601.

(51) **Int. Cl.**[7] .......... **G10D 3/00**
(52) **U.S. Cl.** .......... **84/313**
(58) **Field of Search** .......... 84/298, 307, 313

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,457,201 * 7/1984 Storey .......... 84/313
4,724,737 * 2/1988 Fender .......... 84/313
4,742,750 * 5/1988 Storey .......... 84/313
4,955,275 * 9/1990 Gunn .......... 84/313
5,088,374 * 2/1992 Saijo .......... 84/313

* cited by examiner

*Primary Examiner*—Cassandra C. Spyrou
(74) *Attorney, Agent, or Firm*—Dann, Dorfman, Herrell and Skillman; Stephen H. Eland

(57) **ABSTRACT**

A stringed instrument is provided wherein each string has two critical points. A fulcrum tremolo is mounted on the instrument for varying the tension of the strings and the distance between the two critical points. The strings are attached to a plurality of intonation modules mounted on the fulcrum tremolo. Each intonation module is adjustable so that the strings can be adjusted from an untensioned state to a proper playing pitch. A bearing assembly is also included to facilitate pivoting of the fulcrum tremolo.

**12 Claims, 12 Drawing Sheets**

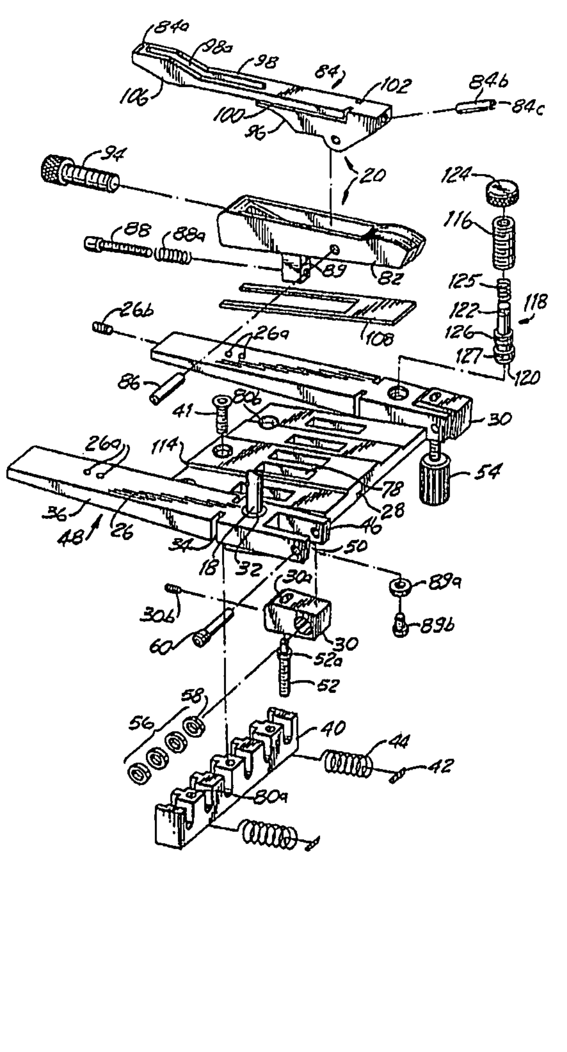
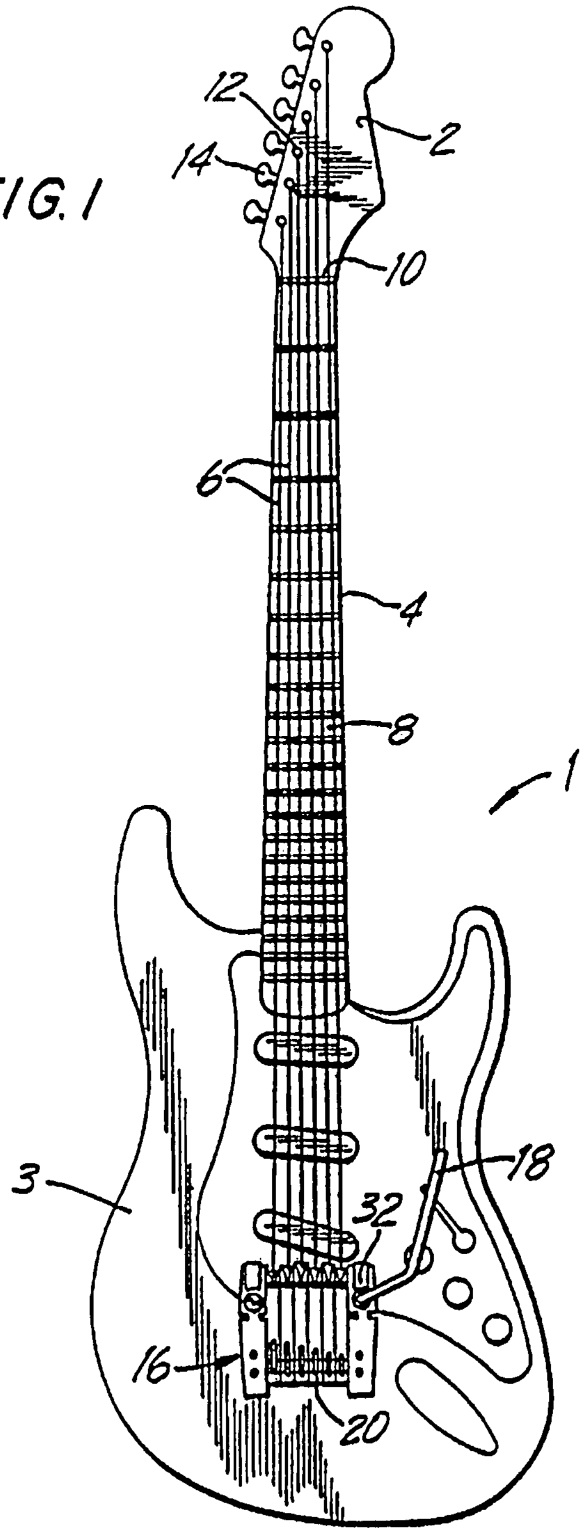


FIG. 1



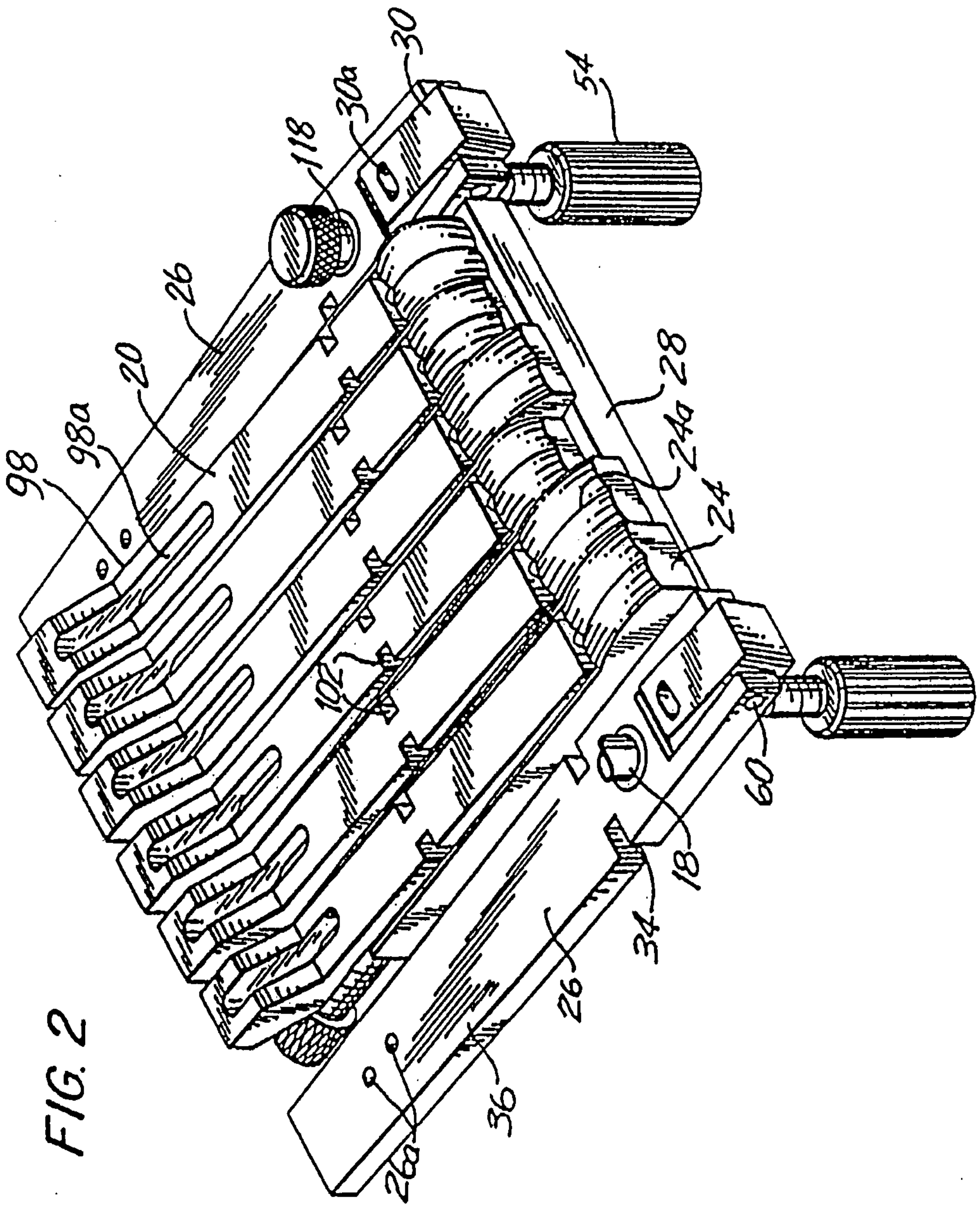
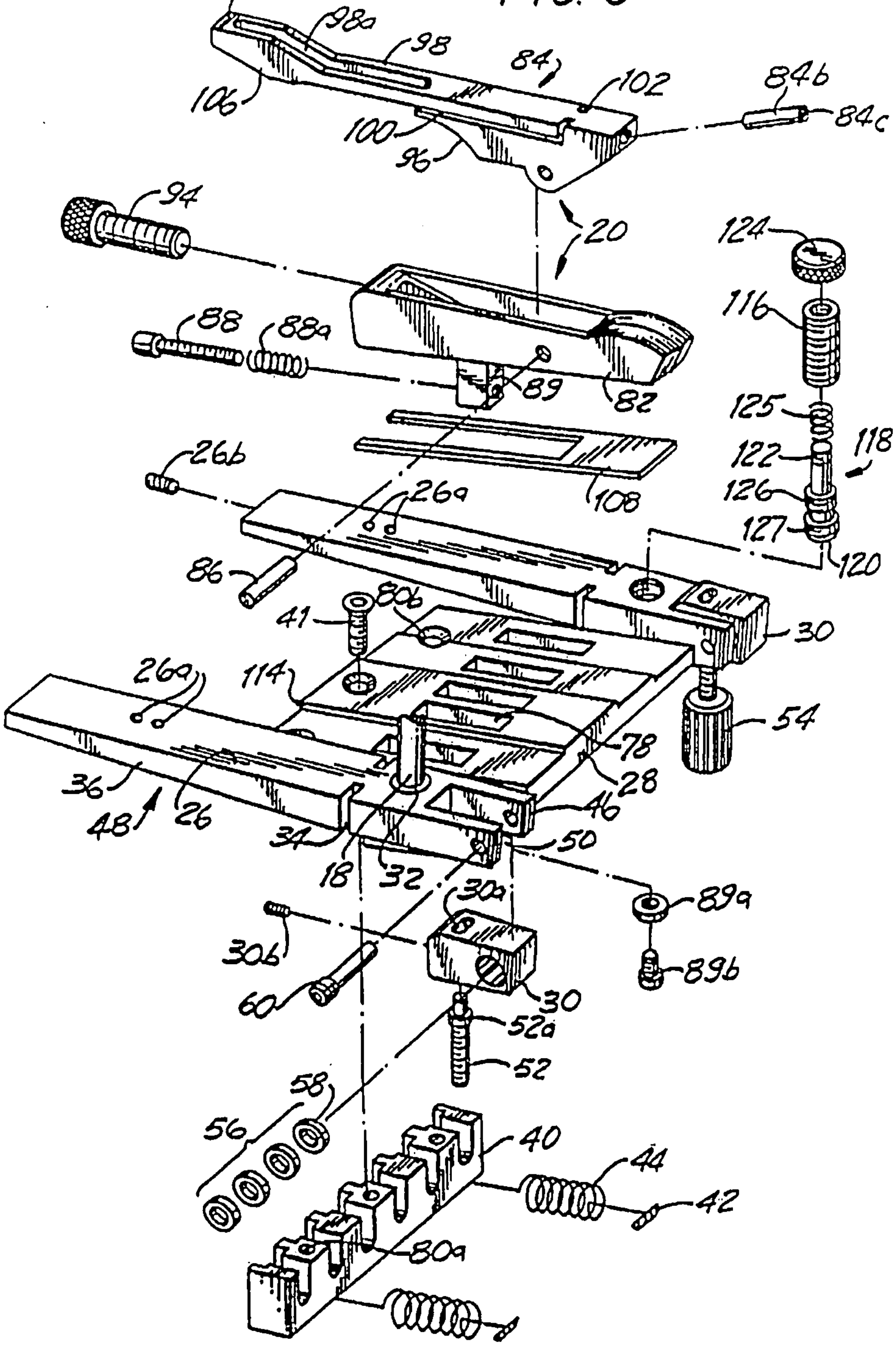



FIG. 2

FIG. 3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84b
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118
26b
26a
108
126
127
120
86
80b
41
30
26a
114
54
78
28
36
46
48
26
34
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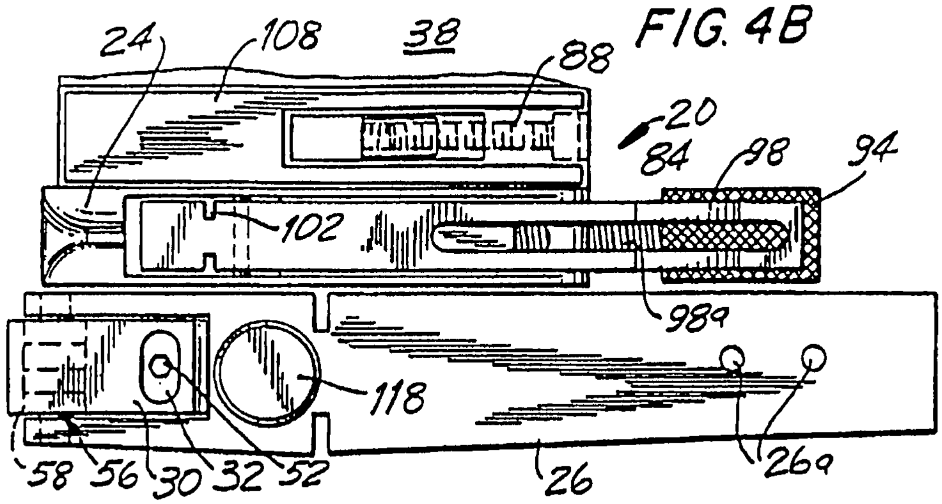
FIG. 4B



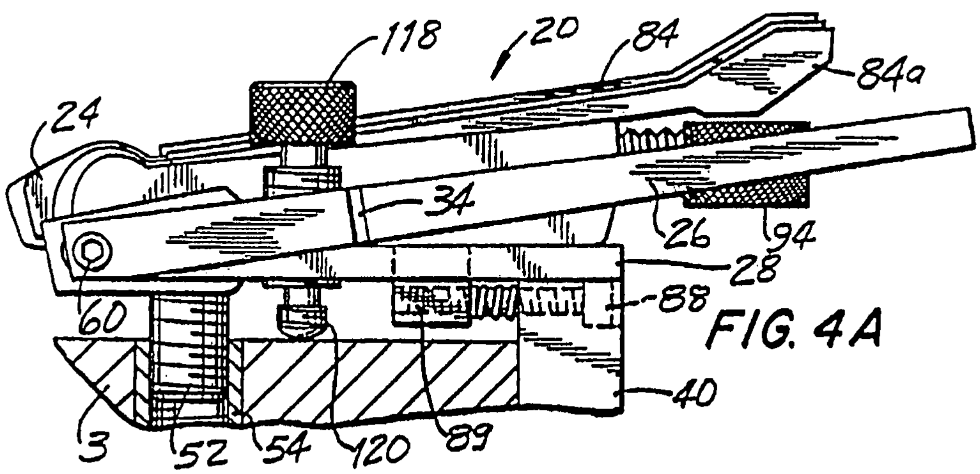




FIG. 4A

FIG. 4C

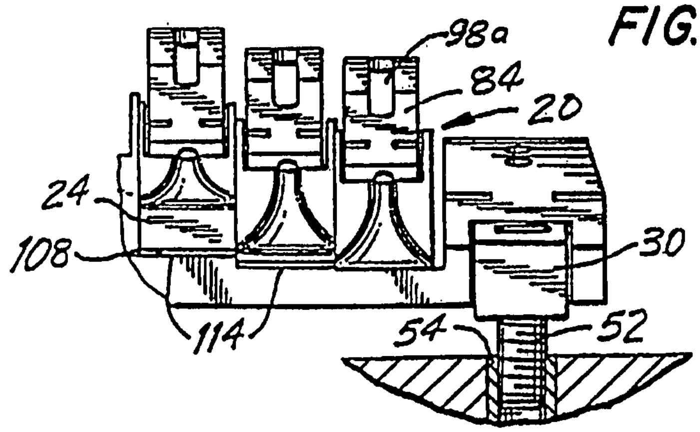


FIG. 5A

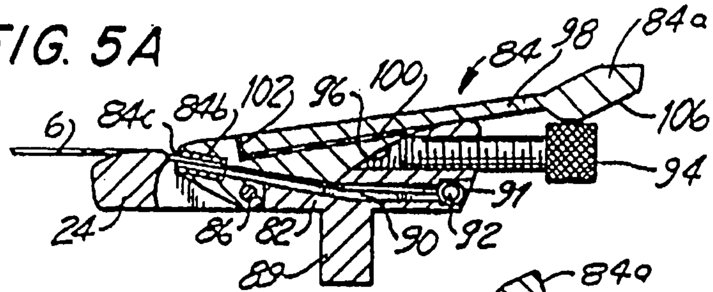



FIG. 5B

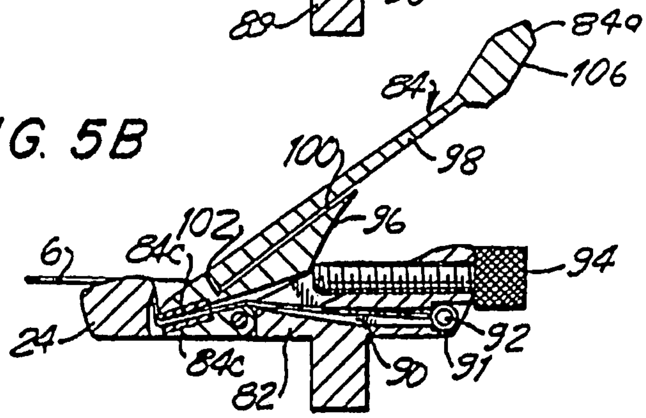



FIG. 7A

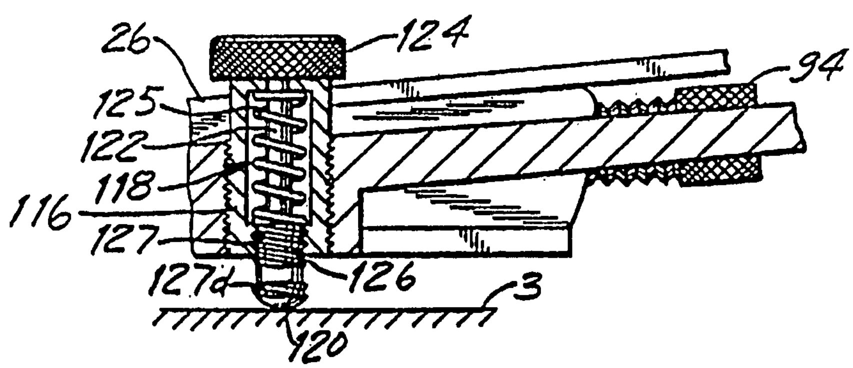



FIG. 7B

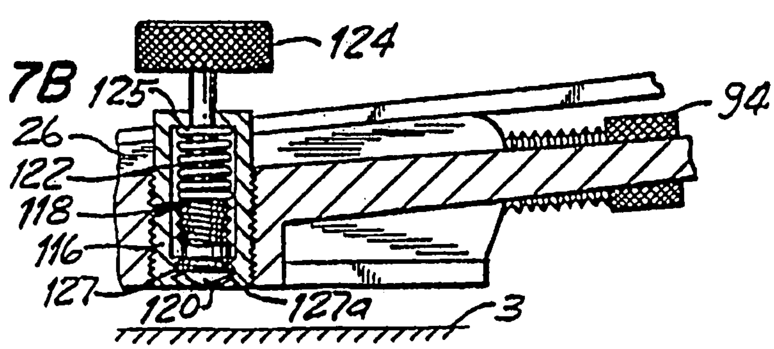


FIG. 6A

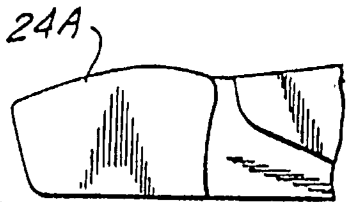



FIG. 6B

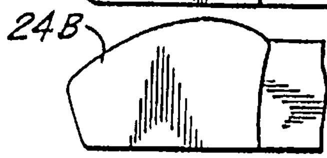



FIG. 6C

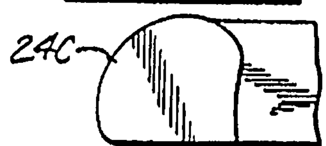



FIG. 6D


FIG. 6E

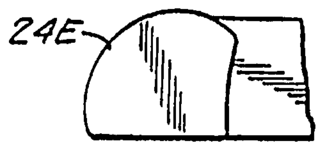
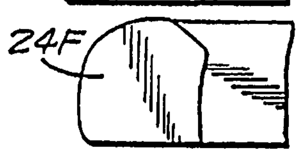



FIG. 6F



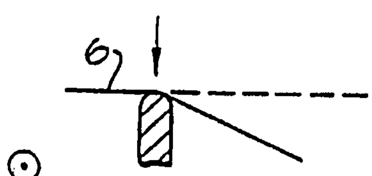




FIG. 6G
PRIOR ART

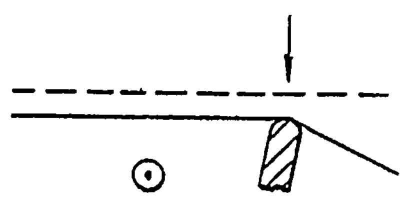


FIG. 6H
PRIOR ART

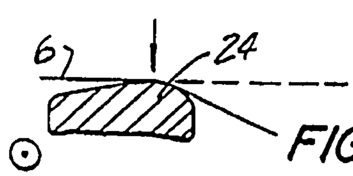



FIG. 6I

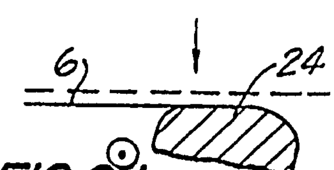



FIG. 6J

FIG. 8A

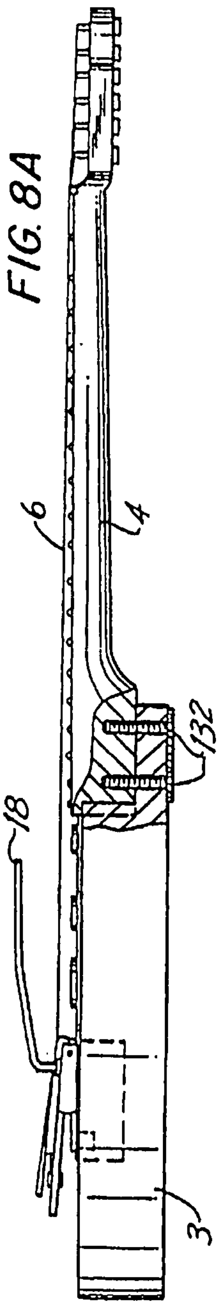



FIG. 8B

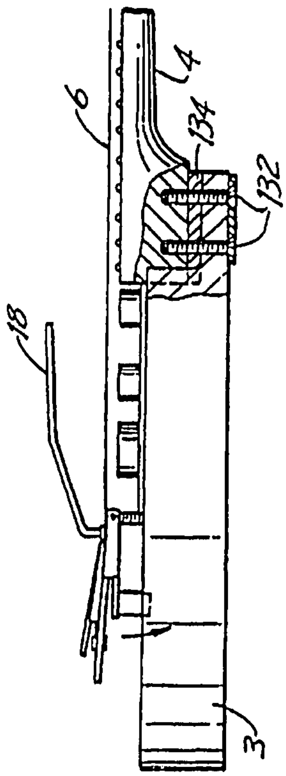
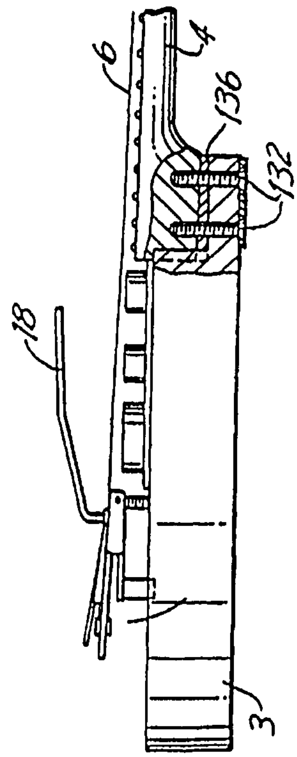



FIG. 8C



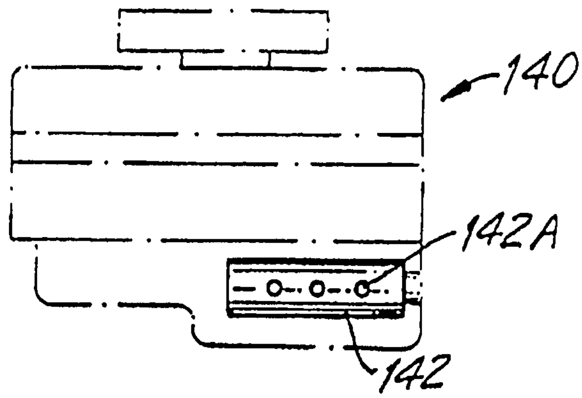
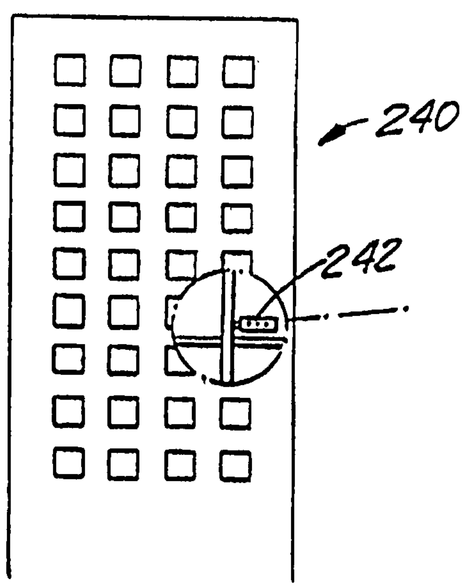



FIG. 9A



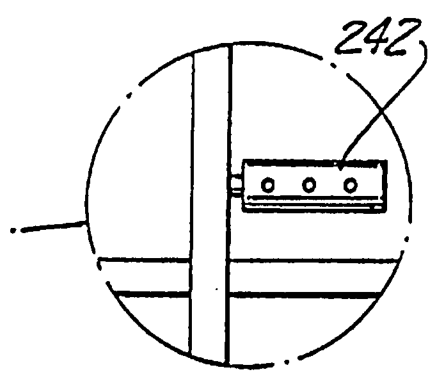




FIG. 9C

FIG. 9B

FIG. 10B-1

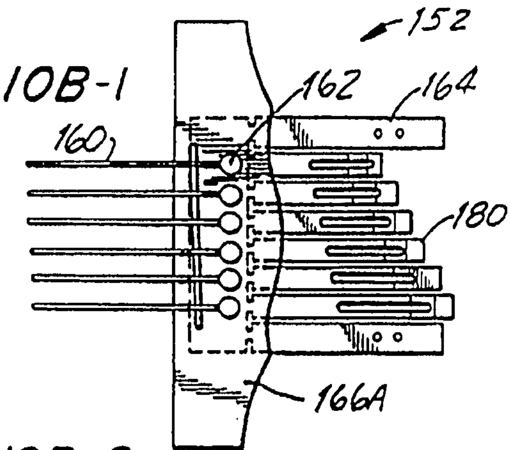



FIG. 10B-2

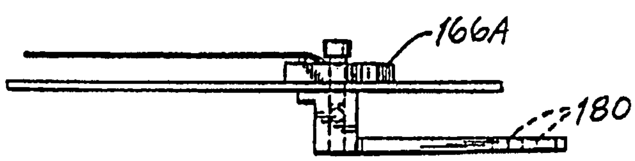



FIG. 10B-3

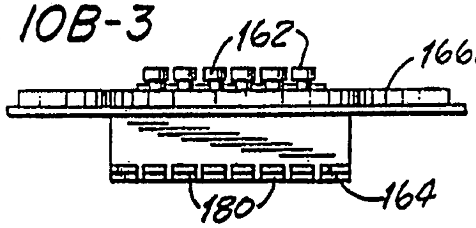
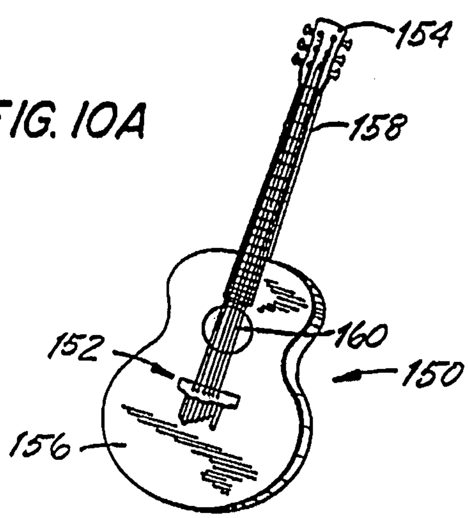



FIG. 10A



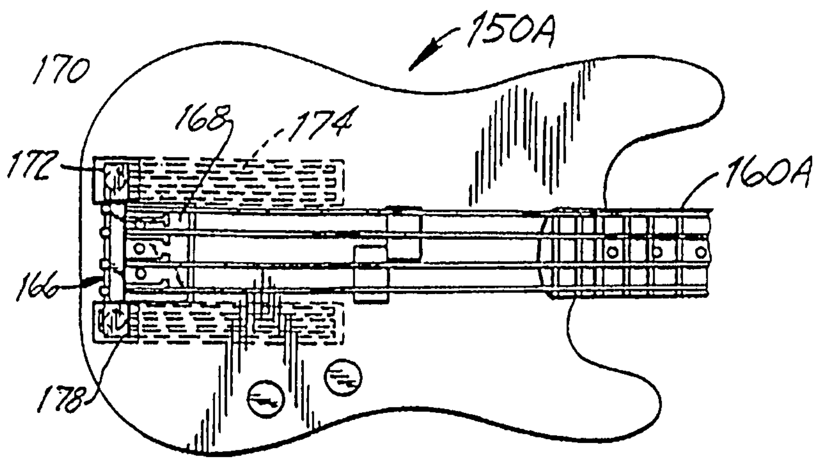



FIG. 10C-1

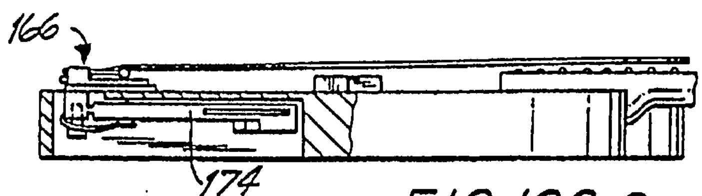



FIG. 10C-2

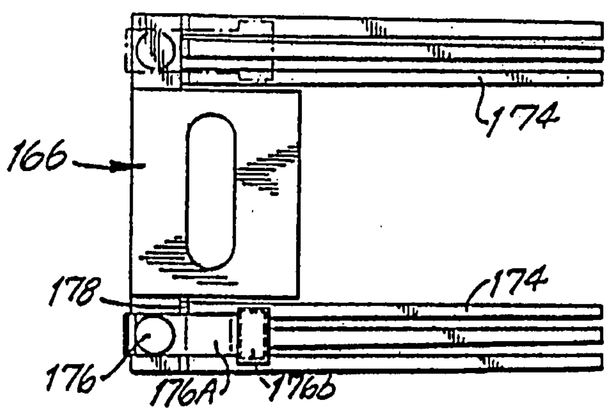



FIG. 10D-1

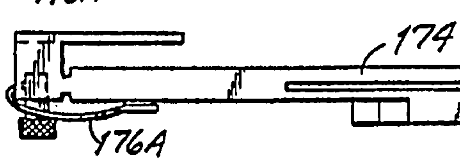



FIG. 10D-2

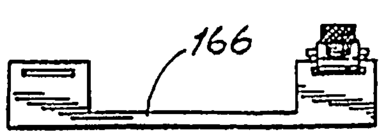



FIG. 10D-3

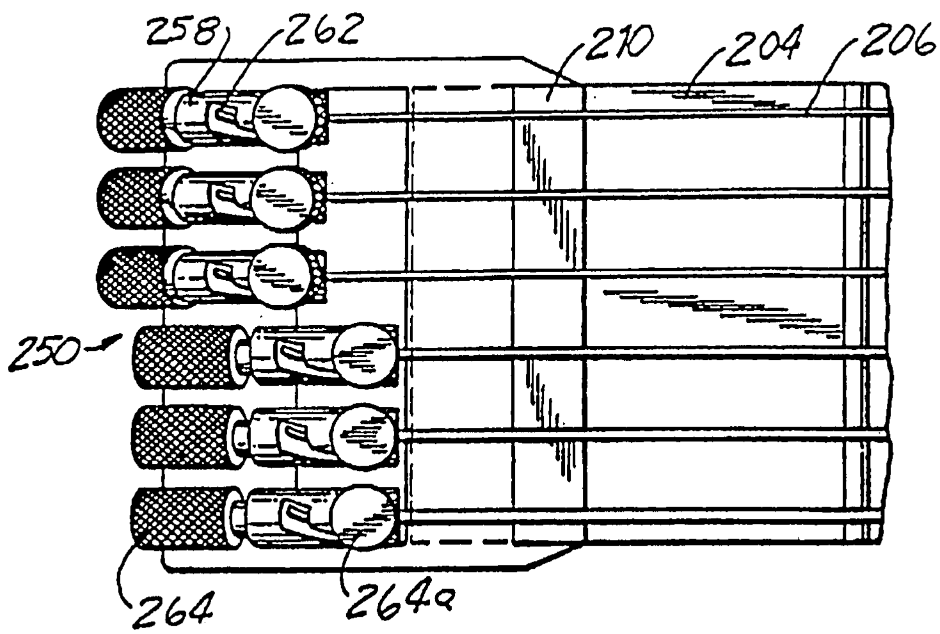



FIG. 11A

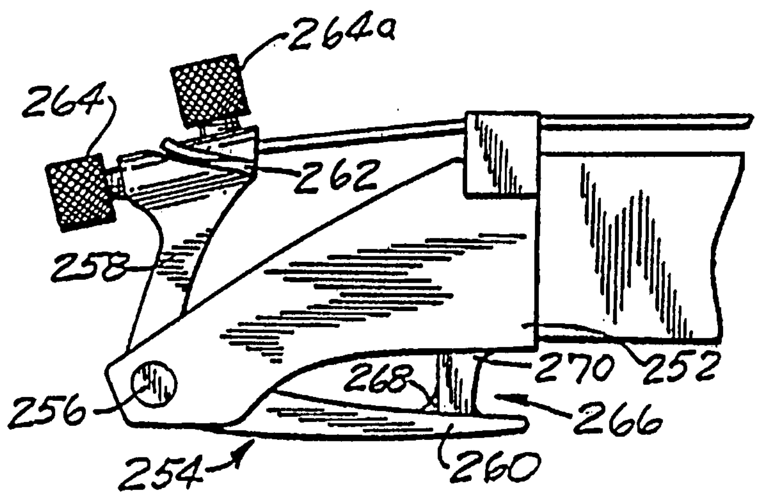



FIG. 11B

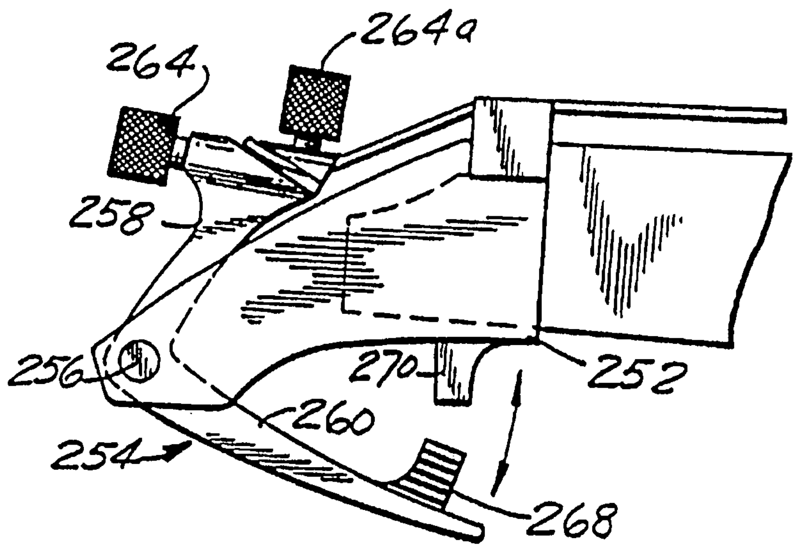



FIG. 11C

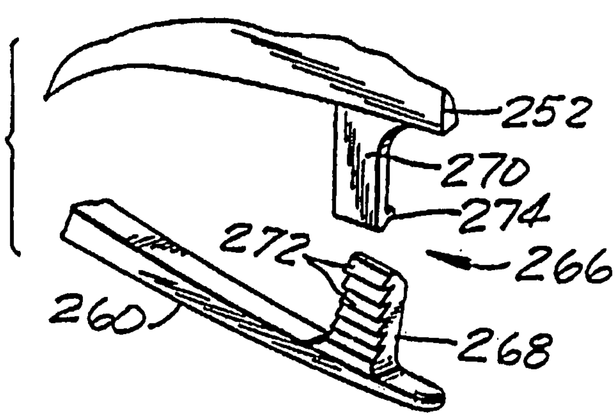



FIG. 11D

## TUNING MEANS FOR STRINGED MUSICAL INSTRUMENT

This Application is a division of Application 607,458, filed Oct. 31, 1990 now U.S. Pat. No. 5,198,601.

### BACKGROUND OF THE INVENTION

The present invention is directed to the tuning of a stringed musical instrument, such as a guitar. Further, it is directed to the use of free-to-vibrate parts in such an instrument for reinforcing and enhancing the vibrating characteristics of the instrument.

Basically, a stringed musical instrument is a hollow wooden box serving as a support for a number of strings secured in tension on an outside surface of the box. When the strings are plucked or bowed, they produce complex vibrations transmitted through the bridge or string supports to the wooden box causing its various surfaces to oscillate and setting in motion the air within, and surrounding the box, causing audible sound. obtaining the desired musical effect can be very difficult. In completely acoustic instruments, as compared to instruments using electronic means for amplification and modifying the tone of the instrument, such as those belonging to the violin family and the folk guitar, the wooden box is constructed to oscillate at a number of determined broad resonances for reinforcing the corresponding range of notes played on the instrument. When the tuning of the instrument is maintained, it will have an apparent increase in volume and sustain and generally will be more pleasing to the ear.

In a stringed musical instrument, such as a guitar, the strings extend unsupported between a first critical point on a neck of the guitar and a second critical point on the guitar body. The first critical point is usually formed by a nut supported in the neck. Generally, the second critical point is formed by a bridge element constituting part of a bridge or a combined bridge and tailpiece assembly. Traditionally, the size of the bridge elements is quite small and functions to clearly define the second critical point and can range from a narrow edge to a rounded surface with a diameter no larger than about 5/32". The strings are typically secured beyond the nut by tuning keys and beyond the bridge element by the tailpiece or tailpiece portion of a bridge and tailpiece assembly. Fine tuning the strings has long been a problem for guitars.

In fine tuning or changing the pitch of a string, two different operations are carried out. In one operation, the length of the string between the first and second critical points is adjusted, such as between the nut and the bridge element, and this is known as harmonic tuning. The second operation involves increasing or decreasing the tension on a given string for raising or lowering the string pitch. This second operation is generally characterized as pitch tuning. In practice, initially harmonic tuning is carried out and then pitch tuning.

A problem existing in tuning the strings is that the two different tuning operations tend to conflict. In harmonic tuning, the pitch is lowered when the distance between the critical points is increased and, conversely, when the distance is shortened, the pitch is raised. In pitch tuning, when the tension is increased, the pitch is raised and when the tension is decreased, the pitch is lowered. These different operations present difficulties in pitch tuning and maintaining the tuned condition of a stringed musical instrument.

When a fulcrum tremolo is used, there is the tendency when increasing string tension and raising of pitch, also to



increase the length of the string, and, conversely, when decreasing string tension and lowering pitch, also to decrease the string length. Accordingly, when using a fulcrum tremolo, these counteracting features are not always balanced.

With the development of the fulcrum tremolo, that is, where the bridge plate is pivoted to provide a tremolo or vibrato effect, the problem of maintaining an effective pivoting action and assuring the return of the bridge plate to an initial position has presented problems. Often, the solution of one problem in pivoting the bridge plate has resulted in the introduction of another problem. As an example, when the bridge plate is pivoted, there is a tendency to upset the harmonic tuning of the strings. Further, the pivot support of the bridge plate, such as disclosed in the Rose U.S. Pat. No. 4,171,661, presented problems in maintaining the proper pivoting action, in returning to the original tuned position, in limiting the range of pivotal movement, and in maintaining the pivot means free from wear. If pivoting of the bridge plate results in wear of the surfaces at which the pivoting action takes place, friction is introduced into the movement of the bridge plate which interferes with its return to the initial position and original tuning.

Combination bridge and tailpiece assemblies have been known for some time. In the Kaufman U.S. Pat. Nos. 1,839,395 and 2,241,911 and in the Beauchamp U.S. Pat. No. 2,152,738, such assemblies were disclosed affording means for varying the tension on the strings and creating a tremolo effect.

In the Proelsdorfer U.S. Pat. No. 2,304,587, string tensioning devices placed on the tailpiece for fine tuning the pitch of the strings of violins, guitars and the like, were disclosed, however, such pitch adjustment is quite limited in range and designed to offer minor adjustment of pitch rather than raising and adjusting from an untensioned condition the strings by the tuners placed on the head of the instrument.

The first fulcrum tremolo combining the bridge and tailpiece was set forth in the Fender U.S. Pat. No. 2,741,146. In this patent, a bevelled ridge portion of the base plate was secured to the instrument body by six screws for permitting limited pivotal movement about the fulcrum and thereby varying the tension on the strings and producing the desired tremolo effect. The strings were supported in the traditional manner on top of the base plate by bridge elements adjustable in height and for string lengths, that is, harmonic tuning. As in known combination bridge and tailpiece assemblies, the strings extend vertically through openings behind the bridge elements and are secured in the tailpiece which in this case also functions to receive the string tensioning biasing springs.

In the Rose U.S. Pat. Nos. 4,171,661 and 4,497,236, two improvements were established. In one improvement, the bevelled ridge portion of the base plate was arranged so that it could be received and held in a tapered slot between the head of the screw and a flanged shoulder, thereby increasing the range of pitch change and improving the return to the initial tuned position and provided for lateral height adjustment of the tremolo. The other improvement involved functionally and physically integrating the bridge elements with the known art of combining fine tuners with anchoring means. In effecting the fine tuning, the bridge elements were provided with a constant radius, so that harmonic tuning would not be effected when establishing fine tuning, however, fine tuning is limited to a range of about two musical pitches and is inadequate for bringing the strings to proper pitch for compensating string stretch, or achieving

common alternate tuning commonly requiring a larger range of pitch change.

In the Shiboya U.S. Pat. No. 4,383,466, a pin was located in a hinge pivot to improve the return to the initial tuned position. This arrangement did not offer lateral height adjustment of the base plate and the field of rotation was not as great as in the Rose improvement.

With these various improvements, a number of problems remained in the known fulcrum tremolo related to the bridge element and its movement when the tremolo is pivoted. Since the second critical point is offset from the pivot axis, initially there is a tendency for the string height at the bridge to decrease when the base plate is pivoted toward the body with the strings contacting the finger board and causing an undesirable buzzing noise and/or deadening the sound of the strings. This phenomenon limits upward pitch change. In addition, there is a tendency for string length to increase when the pitch is raised and for the string length to decrease with the pitch is lowered acting counter to the desired effect. Furthermore, the different diameters and constructi on of the strings on the instrument cause the strings to stretch at different rates and lose pitch relationship.

Concerning this last problem, several improvements have been proposed in the Steinberger U.S. Pat. No. 4,632,005, the Jones U.S. Pat. No. 3,411,394 and the Hussino U.S. Pat. No. 4,648,304, however, none of them are directed toward the fulcrum tremolo. In the installation of the fulcrum tremolo, there is a problem in routing the cavity to receive the tremolo. At least one routing has been required for the biasing springs. A further problem experienced in guitars and, particularly, in electric guitars is establishing a formant where the various resonances of the instrument co-act with the vibrations of the strings to enhance playing quality. Due to centuries of trial and error in the development of the violin body, a very sophisticated formant has been achieved. This has not been the case for the guitar. Particularly in electric guitars, the wooden box can cause unwanted feedback, so that volume of the cavity in the wooden box is often reduced or completely eliminated, as in the case where a solid body is used. As a result, electric guitars depend greatly on electrical amplification for both volume and tone. In the current design theory of electric guitars, the use of metal and especially of steel bridges contribute such mass that it prevents what little resonances the rest of the instrument possesses from having much effect. Accordingly, the tone of such instruments is limited for the most part by the vibrational characteristics of the strings. Another problem is that some players tend to rest their hand on the fulcrum tremolo while playing and inadvertently move the tremolo and detune the instrument.

In stringed musical instruments, the vibration of the strings in combination with the other parts of the instrument, combine to provide the desired tone or sound of the instrument. In the U.S. Pat. No. 3,353,433, to J. D. Webster, a tuning fork is incorporated with a floating bridge arrangement. The bridge arrangement depends from the tuning fork and is supported entirely by the strings of the instruments. Accordingly, when the strings are plucked and set into motion the tuning fork is activated and in turn feeds energy back through the bridge arrangement to the strings, the purpose of which is to keep the strings vibrating as long as the tuning fork vibrates. However, the actual pitch and strength or the vibrating of the tuning fork were not adequately considered and the result was unbalanced at best.

In conventional stringed instruments tuning pegs secure the strings at the head of the instrument. The pegs have an opening through which the string is passed and then tied. Problems exist for conventional peg tuning, such as the amount of peg tightening required and the need for adjustment to compensate for on-going tuning and normal string stretch which takes place during use. As a result, fine tuners have been provided on the bridge or tailpiece. Further, often there is a relatively long distance between the nut and the tuning pegs where the string bends causing unequal tension on opposite sides of the nut and tuning problems. One proposed solution employs string clamps on the nut, however as often happens the string stretches beyond the adjustment range, of the fine tuners. Accordingly, the required correction, is tedious and time consuming involving unclamping, readjusting of the clamp, returning, reclamping and further readjustment.



## SUMMARY OF THE INVENTION

Therefore, one primary object of the present invention is to provide a stringed musical instrument with an improved arrangement for both harmonic tuning and fine tuning of the instrument.

Another primary object of the invention is to provide a sophisticated set of tuned resonances added to the bridge or the combination bridge and tailpiece assembly of the stringed musical instrument, as a functional analogue to the sophisticated formants found in the violin which improve the sustain and resonant quality of the instrument.

Common objects, such as an odd shaped piece of metal when dropped or struck, and set into vibration, usually have an unpleasant or harsh sound. This is characterized by a low tone referred to as the fundamental which can be one specific frequency or several frequencies defining a broad resonance and higher tones or secondary resonances referred to as harmonics. The irregular mathematical relationship between the frequencies of these tones causes the harsh sound as reflected by the irregular shape of the object.

In the case of a metal bar with parallel sides the tone is more pleasing and by removing mass from the middle of the bar the frequencies of higher tones can be tuned to whole number multiples of the frequency of the lower tone as is done in marimbas and xylophones, and the like.

In another variation, strips of metal tightly coupled at one end to a gourd or a similarly fashioned hollow object comprise the African "thumb piano", however, there has been no effort to tune the upper tones to the lower tones and such metal times are directed to producing tones for the instrument, like the strings on a guitar for example, and not for the modification of the resonances of the hollow portion, like the body of the stringed instrument such as a violin. It is known that such a bar tightly coupled at one end has two higher tones that are $6.27\times F_1$ (fundamental) and $17.55\times F_1$, respectively. The tuning fork is actually two bars joined together at one end with each vibrating at approximately the same fundamental. When the fork is tightly coupled to another object the second harmonic drops very close to the fundamental and communicates its vibratory character to the object to which it is coupled. Single bars communicate an influence dependant on the ratio of mass between the bar and the object it is coupled to.

As with the bars of the xylophone, changing the shape of the vibrating object tightly coupled at one end creates the means for functionally tuning its resonant frequencies.

The overall length of the free-to-vibrate portion generally defines the frequency of the lowest tone. Transverse slots can be used to define length. A blind bore in the free end can define the effective length as well.

If the opposite surfaces are tapered toward one another the lowest tones form a broad resonance comprised of many weak frequencies surrounding a strong frequency. Parallel surfaces create one focused low frequency. Removing mass is another way of tuning the higher tones. These recesses can be holes, and when placed close together can form "oval" openings or expanded to slots. Added weight can be used to lower the fundamental resonances whether permanently affixed or adjustable in position.

These means of modifying the character of bars tightly coupled at one end are applicable to changing harmonic content of tuning forks.

A tuning fork or tuning fork-like apparatus of sufficient mass can redefine the resonances of any object to which it is tightly coupled. Additional free-to-vibrate portions of sufficient mass can be tightly coupled to the tuning fork-like apparatus for adding additional resonances. Such a combination can be effective in defining the resonant qualities of any object subject to vibration such as musical instruments.

A further object is to provide individual intonation modules for each string of the instrument affording separate means for the adjustment of harmonic tuning of the bridge portion of the module and macro-tuning of the string attached to the tailpiece portion of the module providing the capacity to bring the strings to proper tension and a tuning range of greater than an octave for use with but not exclusive to "headless" stringed musical instrument, that is, instruments without tuners placed on the head of the instrument.

A further object is to provide two tapered free-to-vibrate portions approximately the same and each with two holes for creating secondary resonances two and three times the strong frequency in the broad resonance and each of approximately the same fundamental resonance tightly coupled to one another and to a musical instrument such that the responsiveness of the musical instrument is defined with no significant resonant peaks or dips other than those created by this tuning fork-like portion.

A further object is that the strong frequency of the tuning fork-like portion is tuned to a pitch of the instrument. For example, it could be a B♭ (B Flat) for a $B^b$ saxophone or $E_2$ or whole number multiple thereof, specifically for this embodiment designed for guitar.

A further object is that the adjustment of the strong frequencies of the tuning fork-like portion is effected either by a set screw in a blind bore in the free end or by a slidable member.

Yet another object, in addition to the tuning fork-like portion, is to provide six additional tapered free-to-vibrate portions coupled to a musical instrument each with a long slot and a broad resonance of an effective range covering a major third (for example concert C to E on the piano) and which strong frequency is tuned between two pitches, (for example between concert C and D flat on the piano) and which slot creates secondary resonances in whole number multiples of the strong frequency.

A still further object is to provide each of six additional free-to-vibrate portions with a different strong frequency spaced a major third from each other and in concert with the secondary resonances, for reinforcing each note on the instrument in a balanced sensitive and responsive manner. The strong frequency in the broad resonance in the series can be tuned to between 220 hz and 390 hz.

Yet another object of the invention is to provide an improved bearing arrangement for a fulcrum tremolo for assuring the proper and wide range of pivotal movement of the tremolo while limiting wear or friction which would tend to defeat the effectiveness of the tremolo.

Still another object is to provide means for limiting the pivoting of the tremolo towards the body.

An additional object is to provide free-to-vibrate portions for a broad range of devices

In the descriptor of the invention the following, terms are used and are defined to assure a proper understanding of the terminology employed.

Resonance refers to vibrations of large amplitude within an object subject to vibration, such as a stringed musical instrument. Other instruments or apparatus are also subject to vibration. In the following description of the invention, an electric guitar is used as the item subject to vibration, however, the invention is also applicable to other vibrating instruments and apparatuses.

Resonant frequency is the frequency of an object subject to vibration when set into motion such that it produces a greater response.

Concert tuned pitch is a pitch derived from a commonly accepted standard, for example, A=440 hz.

The musical interval of a major third is the distance of five musical tones, for example, concert C to E on the piano.

Macro-tuners refer to tuners with the capacity to raise and adjust from an untensioned condition strings to proper playing pitch, providing for alternate tunings, and compensation for substantial string stretch during the life of the string essentially without additional means.

Resonant frequencies are the frequencies where the object subject to vibration has more than one mode of vibration.

Fundamental resonant frequency is the lowest resonant frequency in an object subject to vibration.

Secondary resonant frequencies are the frequencies other than the fundamental.

Overtones, or partials, are resonances of various amplitudes above the fundamental resonant frequency.

Coupled is the connection provided between two vibrating objects which influence one another when they are subject to vibration. The coupled condition can be a loose coupling where the resonances of each object remains unchanged or a tight coupling where the resonances of each object interact very strongly.

Hertz is a unit of frequency of a periodic process equal to one cycle per second.

$E_3$ is usually defined as 164.81 hz when $A_4$ is defined as 440 hz by the International Standards Organization; although in Europe and other parts of the world $A_4$ can vary by up to 25 hz. By this standard $B♭_3$ is 233.08 hz, $B_3$ is 246.94 hz, $D_4$ is 293.66 hz and E♭ is 311.13 hz, etc.

Free-to-vibrate refers to a tuned member coupled to another member and having a portion not coupled or in engagement with the other object.

A tuning fork has two tightly coupled free-to-vibrate bars or sections of approximately the same frequency for creating one fundamental resonance frequency with the first harmonic very close to the fundamental and a second harmonic approximately sixteen times the frequency of the fundamental frequency so that no resonant peaks or dips are present between the fundamental resonant frequency and the harmonics. A tuning fork also has the capacity to impart these characteristics to any object to which it is tightly coupled.

A formant is a fixed array of resonances in which the frequency of the harmonics of the object subject to vibration are emphasized regardless of the fundamental frequency of the vibrational influence on the object.

In a guitar, the strings extend unsupported between a first critical point at the nut mounted in the neck of the guitar and a second critical point at the bridge mounted on the body of the guitar.

In accordance with the present invention, a guitar, preferably an electric guitar, has a body with a neck extending outwardly from the body; usually six strings extend at least from the nut on the neck spaced from the body to some form of anchorage beyond the bridge and mounted on the body. A fulcrum tremolo assembly is mounted over a cavity in the body so that a part of the assembly can be pivoted into the cavity when the tremolo is actuated.

The bridge and tailpiece assembly includes a base plate mounted on the body. The base plate mounts six intonation modules, each arranged to secure one of the strings in its tailpiece portion and to effect the harmonic tuning of the strings. In addition, a wing-like member is located along each of the sides of the base plate, extending in the direction of the strings. Each wing-like member has a first end closer to the neck and a second end more remote from the neck. Adjacent the first end, the wing-like member is directly connected or tightly coupled to the base plate. The wing-like member has a section extending in the direction of the strings from the connected part, away from the neck. The wing-like section has a lower surface facing the body and the lower surface can be tapered upwardly to the rearward free end of the section. The wing-like members are located laterally outwardly from the cavity in the body. Because of their shape, when the bridge plate is pivoted, the wing-like members do not interfere with the pivoting action and do not contact the surface of the body. In the intonation modules the bridge element is functionally separate and physically distanced from the tailpiece portion.

At the connected first end of the wing-like members, the base plate is pivotally supported in a bearing assembly containing ball bearings adjustably mounted so that the plate can be variably spaced from the surface of the body. The bearing assembly includes a self-aligning means to accommodate the variable adjustment of the base plate. Further, instead of at the sides, it is possible to locate the pivot point or pivot axis for the base plate along the front side of the plate facing toward the neck.

Also by using self-aligning bearings or a bearing affording a universal joint type movement, it is possible effectively to pivotally support the base plate, when its axis is not parallel with the surface of the body.

As compared with the knife-edge pivot support of the fulcrum tremolo disclosed in the Rose U.S. Pat. No. 4,171,661, it is possible to limit the wear of the bearing so that unnecessary friction is not developed which would interfere with the return of the base plate to its initial position. In its initial position, the base plate is fine tuned. When the tremolo is pivoted to provide a vibrato effect, the tension on the strings is increased or decreased. When the tremolo arm is released, the tremolo should return to its initial position so that its fine tuned condition is maintained. If the bearing arrangement for the base plate should prevent its return to the initial position, then further adjustment would be needed. In accordance with the present invention, however, ball bearings assure that the bridge assembly returns to the initial position and that wear does not take place which would interfere with the pivotal movement, and offers a greater field of rotation for the largest possible pitch chance.

Existing acoustic physics indicates when two vibrating objects are "tightly" coupled, the resonances of one will influence the resonances of the other. A free-to-vibrate portion of an object set into motion will adopt a resonant frequency and resonances defined primarily by its length and mass. The addition or reduction of mass and its subsequent location along a defined length will change the pitch of the resonant frequency and resonances. Accordingly, the resonant frequency and resonances of an object can be changed based on the characteristics of the free-to-vibrate portion of the other object. As a result, by selecting the structure of the free-to-vibrate portion, it is possible to adjust resonant frequencies in objects subject to vibration.

The control of vibrations has a broad application, not only in musical instruments, such as stringed instruments, but also in speakers and microphones. Moreover, for creating less conflicting energy, such as in engines for vehicles such as motor cars. The control of vibrations can be employed in any device subject to vibration, particularly where the vibrations may tend to have a deleterious effect.

The use of free-to-vibrate portions or elements has preferred application in musical instruments, especially stringed musical instruments.

Musical instruments have tuned resonances for augmenting the energy of a vibrating source. In stringed instruments, a hollow box, usually a wooden box, serves as a support for a number of strings maintained under tension. The box is designed so that its surfaces oscillate producing vibrations in the air within and surrounding it, so that the sound of the vibrating strings are amplified and audible. The oscillating surfaces are arranged to have resonances for reinforcing the vibrations of the strings. In accordance with the present invention, the various parts of the bridge and tailpiece assembly are arranged to enhance the vibrations of the strings.

Various parts of a stringed musical instrument can be selectively configured so as to be free-to-vibrate for augmenting the vibration of the strings, that is, to amplify the energy of the strings. In a preferred embodiment, the free-to-vibrate portions are particularly effective when coupled with the strings or with the bridge elements.

In electric stringed musical instruments, such as electric guitars, the body, which in some instances may not be hollow, does not contribute substantially to the amplification of the instrument. In such instruments, the bridge does not function to transfer the energy of the vibrating string to the body for amplification, rather it reflects the energy back to the string where it is picked up by an electro-magnetic device and amplified electronically. However the use of the bridge for establishing resonances can be most effective when coupling of various free-to-vibrate portions create resonances for reinforcing the vibration of the strings in a manner analogous to the reinforcing effect of a hollow body in a purely acoustic instrument. Since the over-all tonal character of any instrument is effected by the choice of materials, size and shape, and other structural features, the resulting pattern of resonances, its "formant" can be adjusted by these various features to reinforce or modify the sound of the instrument to suit a player's needs.

Free-to-vibrate portions can be a part of the wing-like members on the base plate, a part of the intonation modules mounted on the base plate, part of the structure of the base plate, or other parts connected to the instrument.

The free-to-vibrate portion can be shaped to provide the requisite fundamental resonant frequency. The shape of the free-to-vibrate portion can be a tapered member with the tapering surface being planar or curved. Moreover, weights can be added to the free-to-vibrate portion or mass removed for tuning the fundamental resonant frequency to provide the desired effect. It is also possible, where the free-to-vibrate portion affords its use, to mount a slidable member securable by a set screw on the portion for varying the frequency.

While free-to-vibrate portions can be used for effecting a formant in a stringed musical instrument, such parts can also

be employed for controlling the vibration of other objects, such as an automobile engine or even a building or other large structure. In the operation of an automobile engine, or of many other mechanical devices, it is possible for vibrations to develop which have a deleterious effect on the continued operation of the device. By providing the proper free-to-vibrate portions on a vibrating-device, the range of vibrations can be kept within certain limits or tuned for limiting or avoiding damage.

A significant feature of the use of the free-to-vibrate portion is that it is tightly coupled to the vibrating object for achieving the desired result. As pointed out above, the wing-like member forming the free-to-vibrate portion, is formed integrally with the base plate. Without the tightly coupled connection, the influence of the free-to-vibrate portion is not achieved.

Another preferred feature of the invention is the arrangement of the intonation modules on the base plate for providing harmonic and pitch tuning of the individual strings and also for influencing the vibration of the strings by incorporating free-to-vibrate portions as a part of the intonation modules.

The intonation modules are slidably mounted in slots in the base plate for effecting the desired harmonic tuning, that is, for fixing the string length between the first and second critical points. Each intonation module can be separately locked in position establishing the desired length between the critical points.

The second critical point is formed by a bridge element constructed as a part of the intonation module, though it is functionally separate from the rest of the module. The bridge element is connected to a base elongated in the direction of the strings. The base is slidably connected to the base plate and is secured to the base plate after the harmonic tuning is effected. The intonation module base has a front or first end on which the bridge element is formed and it extends away from the bridge element toward the rear end of the body, that is, the opposite end from the neck. The bridge element forms the second critical point. An important feature of the bridge element is its varied curved surface contacted by the string.

A significant feature of the invention is the manner in which the curved surface is formed. In the initial position of the tremolo, the second critical point divides the curved surface into a first section closer to the neck and a second section more remote from the neck. When the base plate is pivoted, the intonation modules and, as a result, the bridge elements pivot with it so that the location of the second critical point changes, increasing or decreasing the tension on the strings. Since the strings each have a different cross-sectional size, there is a variable tensioning effect on the strings. To maintain the fine tuned character of the strings relative to one another, each of the enlarged curved surfaces of the bridge elements are varied relative to one another so that each of the second critical points travels along the surface in differing distances and thereby selectively changing the harmonic tuning. By providing the proper ratio between each of the enlarged curved surfaces on each of the bridge elements, it is possible to compensate for uneven string stretch and maintain the relative harmonic tuning between the strings during the pivoting movement of the tremolo. Furthermore, by increasing the radius of the first section relative to the radius of the second section the upward pitch change can be further augmented. Lastly, by varying the radii continuously a smooth transition from the first section to the second section can be achieved.

Another important feature of the invention is the increased radial size of the bridge elements for maintaining



the string height relative to the fingerboard when the tremolo is used. Accordingly, the bridge elements cannot contain rotatable parts, since harmonic tuning would be disturbed in the initial position. Consequently, the bridge elements must be functionally separate from the tailpiece. Further, the strings must slide over the bridge elements during change of tension in the fine tuning.

Another object of the invention compared to the prior art is to provide a shortened spring block or the base plate, moved rearwardly and fitted with smaller string tension biasing springs, so that the whole assembly can be fitted into a single cavity in the body of the instrument below the base plate. This feature simplifies routing of the body.

Still another object of the invention is to provide a stepped base plate and shims for adjusting the height of the bridge elements and for maintaining tight coupling between the bridge elements and the base plate.

Each intonation module has a lever-like tine member pivotally connected to the base adjacent the bridge element, with the tine member extending from the pivot point toward the rear end of the guitar body. A passage is provided through the tine member for receiving the string after it passes over the bridge element, with the string being anchored at the rear end of the passage in the tailpiece part. By pivoting the tine member, the tension on the string can be varied. The pivoting of the lever-like tine member, can be effected by an adjustment member mounted on the base. The tine member has a curved surface extending toward the rear end of the body. The adjustment member can be threaded into the base and into contact with the curved surface and such contact causes the lever-like tine member to pivot about its connection to the base. As a result, the orientation of the passage through the lever-like member can be altered so that the tension of the string passing through it is also changed. Further, the forward tips of the lever-like tine pivot under the bridge element for dramatically increasing the potential of the tension effected by the adjustment member. Accordingly, macro-tuning of the individual strings can be achieved by the adjustment member.

It is also possible to form a rear part of the lever-like member as a free-to-vibrate portion for adding resonances to the bridge and tailpiece assembly. The free-to-vibrate portion of the lever-like tine member can be shaped to provide the desired fundamental resonant frequency. The combination of the free-to-vibrate portions on the base plate and in the intonation modules provide a formant in the instrument.

The base plate is formed of a first part extending generally parallel to the surface of the guitar body and a second part disposed perpendicular to the rear end of the first part and extending downwardly from it into the recess in the body. The second part is connected to spring means within the cavity for effecting the return of the tremolo or bridge assembly into the initial position after the tremolo has been pivoted and released.

The tremolo is pivoted by a tremolo arm secured to one wing-like member of the base plate. An insert is formed in the wing-like member into which the tremolo arm can fit.

To avoid accidental displacement of the tremolo arm, a releasable lock secures it in its initial position until the tremolo arm is to be intentionally pivoted.

Still another significant feature of the invention is the creation of a sophisticated set of tuned resonances in the bridge or the bridge and tailpiece assembly of a stringed musical instrument. In one preferred embodiment, means are provided for creating a formant in the vibration of the guitar as it is played. The desired effect can be achieved by using

tapered free-to-vibrate portions tightly coupled to the bridge or bridge and tailpiece assembly. With at least two tapered free-to-vibrate portions each having a broad resonance and a strong central resonance frequency adopting characteristics of a tuning fork, the second harmonic drops from approximately six times the fundamental to within a few Hertz of the fundamental removing any other resonant peaks or dips, other than the third harmonic which relatively is not influential for the bridge mass, since this tuning fork-like apparatus vibrates for an extended period it will keep its secondary resonances created by two cylindrical holes in each tapered free-to-vibrate portion and any other free-to-vibrate portion coupled thereto vibrating and active.

In addition, six other free-to-vibrate portions or tine members are arranged as part of the intonation modules, each tuned to have a broad resonance with its own harmonics or secondary resonances. When secondary resonances from any two or more tine members are placed close to one another harmonically, they simulate the effect of a fundamental broad resonance. By properly tuning the tine members, the tuning fork portions, and their secondary resonances, a formant is established, fully reinforcing the vibrations of any note played on the instrument in a balanced manner and providing exceptional volume, tone and sustain as in great violins.

Since the free-to-vibrate portions are tuned to react with a wide range of frequencies, they act like sensitive antennae vibrating sympathetically to the sound produced by the speakers in the electric amplification means. This increased sensitivity allows for outstanding sustain with lower amplifier distortion at lower playing volumes than would be otherwise possible.

Aluminum alloys are particularly effective in forming the free-to-vibrate portions and afford greater sensitivity than other materials. Stainless steel can also be used for any of the parts of the bridge, or bridge and tailpiece assembly, due to their ability to couple extremely well. Further, stainless steel is relatively free from wear.

Although the invention is described with respect to metal guitar bridges and more specifically fulcrum tremolos, it is equally possible to create free-to-vibrate portions out of wood or synthetic materials such as reinforced graphite, especially for use in purely or semi-acoustic instruments.

Choice of materials in the construction of musical instruments has always been important. As scientific advances and new developments in materials continue to evolve at a brisk rate, their application can be directed to the use of free-to-vibrate portions coupled to musical instruments.

The use of steel, brass and bronze is very common in musical instruments and steel has become the favored material for stringed musical instrument bridges, because of its bright sound, great mass and durability. Accordingly, steel is a suitable material for the present invention, however, for the first time aluminum can be utilized as it shares the same stiffness to mass ratio as steel but will afford a softer sounding, more responsive and resonant response and, depending on the player, may be preferred.

Further, recent advances in ceramics have been outstanding and have produced entire automobile engines. Commercial applications of ceramics are becoming increasingly common in everyday life, for example, reasonably priced bells and knives are available where steel has been replaced by ceramic materials. As ceramics are more readily moldable and offer acoustic properties similar to steel, they can be used for all bridge parts from the intonation module base to the free-to-vibrate portions.

In some applications, particularly those directed toward non-electric or purely acoustic instruments, other materials may be desirable. Certainly, wood is the most obvious choice, throughout history its superior qualities have been demonstrated. Plastics and composites, such as graphite epoxy, have been used successfully to create sound boards for guitars and violins where the mechanical properties of a composite sandwich plate with graphite-epoxy facings and a low density core closely matched those of a conventional spruce plate. Such materials could be used effectively and economically to produce high quality free-to-vibrate resonant plates and bridges of a consistent level.

Another primary object of the present invention is to provide an adjustment device for bringing the strings to pitch at one of several coarse tunings quickly and then fine tuned by separate means.

A tuning adjustment device is provided for securing the string at the head of the instrument and then making a fine tuning adjustment by means of a thumb screw. The tuning device is pivoted on the head end of the stringed instrument and is movable between several tensioned positions and a untensioned or released position. In the tension position the anchorage for the string is located relatively close to the nut at the head end of the instrument so that little bending of the string takes place.

The tuning device is formed as a two armed L-shaped lever pivotally mounted on a bracket secured to the head end of the instrument in the region of the nut. The string is secured at a free end of one arm of the lever and a locking means for the device is provided adjacent the free end of the other lever arm. The locking means is in the form of a forceps-like clamp containing a plurality of teeth so that each tooth provides a different locking position. By changing the locking position the tension on the string can be quickly increased or decreased as required for providing preset pitch changes.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a plan view of an electric guitar embodying the present invention;

FIG. 2 is a perspective view of a tremolo-bridge-tailpiece assembly as used in the guitar of FIG. 1;

FIG. 3 is an exploded perspective view of the tremolo-bridge-tailpiece assembly in FIG. 2;

FIG. 4A is a side view of the bridge-tailpiece assembly of FIG. 2;

FIG. 4B is a partial plan view of the bridge-tailpiece assembly of FIG. 3A;

FIG. 4C is a partial end view of the bridge-tailpiece assembly of FIG. 3A;

FIGS. 5A and 5B are side views illustrating the range of displacement of a lever member in the intonation module;

FIGS. 6A, B, C, D, E and F are cross-sectional views of the different bridge elements mounted on the intonation modules as shown in FIG. 1 and FIG. 2;

FIGS. 6G and 6H are schematic illustrations of a bridge element showing the prior art;

FIGS. **6I** and **6J** are schematic illustrations of the bridge elements of the present invention;

FIG. **7A** is a side view, partly in section, of a retractable tremolo limiter in a limiting position;

FIG. **7B** is a side view, similar to FIG. **7A**, however, showing the tremolo free to pivot;

FIG. **8A** is a partial side view of a guitar with a "bolt-on" neck;

FIG. **8B** is a view similar to FIG. **8A** with a flat shim;

FIG. **8C** is a view similar to FIG. **8B** with a wedge shim;

FIG. **9A** is a side view of an engine with an attached free-to-vibrate section;

FIG. **9B** is a view of a building frame with a free-to-vibrate portion;

FIG. **9C** is an enlarged detail view of the encircled part in FIG. **9C**;

FIG. **10A** is a perspective view of an acoustic guitar with a resonance bridge;

FIG. **10B** is an enlarged partial plan view of the acoustic guitar and resonance bridge;

FIG. **10C** is a side view of the acoustic guitar and resonance plate;

FIG. **10D** is a plan view of the resonance plate separate from the bridge;

FIG. **11A** is a plan view of a plurality of adjustment tuning devices for use on a stringed instrument;

FIG. **11B** is a side view of one of the devices shown with the string in the tensioned position;

FIG. **11C** is a side view, similar to FIG. **11B**, however, with the string in the unlocked or released position; and

FIG. **11D** is a detailed view, on an enlarged scale, on a locking means for the device.

## DETAILED DESCRIPTION OF THE INVENTION

In FIG. **1**, an electric guitar **1** is illustrated comprising a head **2** at one end, a body **3** at the other end, with a neck **4** extending between the head and the body. Six strings **6** extend from the head **2** to the body **3** over the neck **4**. The neck **4** forms a fret board **8** for the guitar. At the head, each of the strings extends over a nut **10** forming the first critical point for the strings. The nut **10** is located at the transition from the neck **4** to the head **2**. Each of the strings **6** is anchored on the head by an anchor **12** and each anchor has a corresponding tuner or tuning peg **14**. On the body **3**, the strings **6** are secured to a bridge-tailpiece assembly **16**. The bridge-tailpiece assembly is a fulcrum tremolo with an arm **18** for pivoting the fulcrum tremolo and providing a vibrato effect on the strings. The bridge-tailpiece assembly **16** includes six intonation modules **20**.

In the body **3** of the guitar there are electric pick-ups.

In the following description, the bridge-tailpiece assembly **16** will be described in greater detail.

The bridge-tailpiece assembly **16** forms a second critical point for the strings **6**, sometimes characterized as an intonation point or bridge point.

In FIG. **2**, the bridge-tailpiece assembly **16** or fulcrum tremolo is shown on an enlarged scale as compared to FIG. **1**. FIG. **3** displays the bridge-tailpiece assembly **16** of FIG. **2** in an exploded view. The second critical point is located at the front end of the assembly **16** extending across the bridge elements **24**. There is a separate bridge element **24** for each of the intonation modules **20**. Outwardly from the



intonation modules **20** on each side of the opposite sides extending in the string direction, there are two wing elements **26**. The wing elements **26** are formed integrally with a main stepped plate **28**. Each of the wing elements **26** is supported on a bearing housing **30**. The bearing housings **30** pivotally support the stepped base bridge plate **28**. The tremolo arm **18**, shown only in part, is secured within an arm insert **32** and pivots the assembly **16** relative to the bearing housings **30**.

Each wing element **26** is secured integrally with the main bridge plate **28** in the region of the bearing housing **30** and the arm insert **32**. Immediately behind the arm insert **32** are slits **34** extending transversely of the long direction of the wing elements, that is, transversely of the direction of the strings **6**, and partially separating a free-to-vibrate portion **36**, from the portion of the wing element **26** secured to the stepped base plate **28**.

As can be seen in FIG. **9**, the body **3** has a routed opening **38** located below the bridge-tailpiece assembly **16**, with a spring block **40** secured by bolts **41** to the stepped base plate **28** and extending downwardly from it, into the routed opening **38**. A spring plate **42**, shown only schematically, is secured within the routed opening **38** below the stepped base plate and spaced slightly rearwardly from the bridge elements **24**. Springs **44** extend between the spring plate **42** and the spring block **40** for returning the bridge-tailpiece assembly **16** back to its original position, after it has been pivoted by the tremolo arm **18**.

The wing elements **26** extend generally parallel with the intonation modules **20** and with the strings **6**. Each wing element **26** is pivotally supported by its bearing housing **30**. The forward portion **46** of the wing element **26**, located closer to the neck **4**, is formed integrally with the stepped base plate **28**.

The forward portion **46** of the wing element **26** is fairly massive, while the rearward portion **48** tapers from the forward portion, separated partly from it by slits **34**, into a relatively thin section forming the free-to-vibrate portion **36**. Transverse to the string direction, the wing elements **26** are relatively wide, being somewhat wider than the intonation modules **20**. The rearward portion **48** or free-to-vibrate portion **36** is separated from the stepped base plate **28**.

The free-to-vibrate portion **36** is shaped to provide the desired resonance for enhancing the vibration of the strings and improving the tone of the guitar. The free-to-vibrate portion **36** can have curved or tapered surfaces. In addition to the shape of the free-to-vibrate portion, the desired resonance characteristic can be achieved by drilling single or multiple holes **26*a*** in the portion, and by adding mass to or removing mass from the portion **36**. The holes **26*a*** can be joined together to form elongated slots intermediate the ends of the free-to-vibrate portion or extending from the free end toward the coupled end. In FIG. **3** a set screw **26*b*** is inserted into a threaded hole, not shown, for fine tuning the pitch of the free-to-vibrate portion.

In FIGS. **2, 3** and **4A–4C**, the bearing housing **30** is shown at the forward end of the wing element **26**. The bearing housing **30** fits into a cut-out **50** in the forward end of the wing element **26**. The housing **30** is adjustably supported relative to the body **3** of the guitar by a threaded post **52** with annular flange **52*a***. Post **52** is threaded into a housing insert **54** in the body **3** of the guitar, note FIGS. **4A** and **4C**. By adjusting the extent of the threaded engagement for the post **52** into the body insert **54**, the spacing between the body **30** and the surface of the body **3** is selectively adjustable. Adjustment of the post **52** is effected through an oval

opening **30***a* in the top of the housing **30**. The oval shape permits relative movement between the post **52** and the housing **30**. A set screw **30***b* fits into the rear end of the housing **30** to secure the post **52**. In the housing **30**, forwardly of the post **52**, there is an opening through the housing extending transversely of the string direction of the guitar containing a quad-stack bearing assembly **56**, formed by four side-by-side roller bearings **58**. A pin or shaft **60** is threaded into one side of the wing element **26** and extends through the bearings **58** into the wing element on the opposite side of the recess **50**. Accordingly, by manipulating the tremolo arm **18**, the bridge-tailpiece assembly **16** or fulcrum tremolo can be pivoted about the pin **60** to achieve the desired effect when playing the guitar.

While a quad-stack bearing assembly **56** is shown for pivotally supporting the bridge-tailpiece assembly **16**, a variety of pivot bearings could be employed. A significant feature is that the bearing assembly permits the displacement of the bridge-tailpiece assembly with the pivot axes of the pins **60** not parallel to the surface of the body **3**. This feature is important when the bearing housings **30** on the opposite sides of the bridge-tailpiece assembly each have a different height above the body surface of the guitar.

As shown in FIG. **3**, the sleeve-like arm insert **32** is threadably secured in the forward portion **46** of the wing element. The arm **18** is threadably secured in the insert. By means of the arm, the bridge tailpiece assembly **16** is pivoted.

In FIG. **3**, the stepped base plate **28** is shown with the attached wing elements **26**. Note that the free-to-vibrate portions **36** are separate from the main bridge plate and are partially separated from the forward portion **46** by the slits **34**. The main bridge plate **28** includes the spring block **40** located at the rearward end of the plate, that is, the end more remote from the neck of the guitar.

Approximately in line transversely of the string direction with the insert **32**, are six rectangular openings **78**, note FIG. **3**. Each of these openings receives a portion **89** of each of the intonation modules **20** to be described later.

In FIG. **3**, a portion of the tremolo arm **18** is shown extending upwardly from the insert **32** for effecting the pivoting action of the bridge-tailpiece assembly **16**. The spring block **40** is provided with screw holes **80***a* aligned with screw holes **80***b* in the base plate **28** to receive bolts **41** for securing the block to the plate. The springs **44** are secured to and extend between the spring plate **42** and the spring block **40**. The springs **44** return the bridge-tailpiece assembly **16** to its original position after the tremolo arm **18** is released following pivotal displacement of the assembly.

In FIG. **3**, one of the intonation modules **20** is shown, including a base **82** with a bridge element **24** located on the right hand end of the base. A lever member **84** is pivoted to the base by a pivot pin **86**. The base **82** is adjustably secured to the spring block **40** of base plate **28** of the bridge-tailpiece assembly **16** by a bolt **88** and spring **88***a*. The bolt **88** is supported in the spring block **40** and is threaded into a projection **89** on the base **82** extending through an opening Spring **88***a* encircles the bolt **88** between the block **40** and the projection **89**. By turning the bolt **88** the position of the intonation module relative to the base plate **28** can be adjusted. As can be seen in FIG. **2**, the openings **78** are elongated in the string direction and permit adjustment of the intonation module in that direction for effecting harmonic tuning. The positions of individual intonation modules can be adjusted by turning the bolts **88**. The projecting **89** is secured at the under side of the base plate **28** by a washer **89***a* and a bolt **89***b* threadably secured and into the underside the base **82**.



The bridge element **24** has a recessed variably curved portion **24***a*, note FIG. **3**, in which the corresponding string **6** seats as it moves over the bridge element. From its point of contact with the bridge element **24**, that is, at the second critical point, the string **6** moves downwardly into an elongated passageway **90** extending first through lever member **84** and then through the base **82** from adjacent and just rearwardly of the bridge element **24** to the rearward end of the base, note FIGS. **5A** and **5B**. At the front end of the lever member **84**, at the entrance into the passageway **90** there is a stainless steel sleeve **84***b* which forms a wear resistant surface for the strings **6**. At the rearward end of the passageway **90**, an enlarged recess **91** in the base **82** is provided for an anchor **92** securing the ball end of the string **6**.

An adjustment screw **94** is threaded into the rearward end of the base **82** into engagement with a surface **96** of the lever member **84**. In FIG. **5A**, the adjustment screw **94** contacts the surface **96** so that the string **6** is in contact with the surface **96** at its intersection with the passageway **90**. This position is the rearwardmost point of contact of the string within the passageway **90** with the lever member **84**.

In FIG. **5B**, the maximum range of upward displacement of the lever member **84** is shown. As the lever member **84** is pivoted upwardly by threading the adjustment screw **94** forwardly into the base **82**, the sleeve **84***b* in the forward end of the passageway **90**, that is, the forward end of the lever member **84**, contacts the string **6** and presses it downwardly providing an adjustment in the pitch tuning of the string by varying the tension or pull exerted on the string. The contact of the string **6** with the surface of the corresponding bridge element **24** is also varied. As the adjustment screw **94** is moved between the two limiting positions, shown in FIGS. **5A** and **5B**, the tension on the string **6** is varied.

The lever member **84** has a free-to-vibrate portion **98** formed by a slit **100** in the lever member extending in the string direction from a rearward part of the surface **96** to a point approximately above the pivot pin **86**. Slits **102** extending transversely of the slit **100** pass through the lever member connecting the slit **100** with the upper surface of the lever member. The slits **102** can be seen in FIGS. **2**, **3**, **5A** and **5B**. The free-to-vibrate section **98** of the lever member **84** extends from the slits **102** to the rearward end of the lever member **84** where the free end **84***a* is enlarged to form a mass **106** for obtaining the desired resonance effect for the lever member. Slots **98***a* can be formed in the broad surface of the free-to-vibrate section **98** of the lever member **84** for achieving the desired resonance effect.

While only a single intonation module is illustrated in FIGS. **3**, **5A** and **5B**, the lever members **84** for each of the intonation modules can be selectively shaped to afford the desired resonance effect for the whole bridge tailpiece assembly. The combination of the resonance effects of the lever members **84** added to the resonance effects of the tuning fork-like tapered wing elements **26** provides a fornant for the guitar not previously attainable.

In the bridge-tailpiece assembly **16**, the tailpiece afforded by the rearward end of the base **82** of each intonation module **20** is functionally separated from the bridge element **24** located on the forward end of the corresponding intonation module.

In the past, any adjustment available in the bridge-tailpiece assembly has been limited to fine tuning, usually less than a range of three pitches where the octave has twelve pitches. With the adjustment screws **94** of each

intonation module **20**, it is possible to obtain macro tuning where the range extends over a full octave creating a means to bring from an untensioned condition of the string to proper playing pitch. With this arrangement, it is possible to eliminate the tuning pegs at the opposite end of the guitar and provide what has been characterized as a "headless" guitar. With the range of displacement of the lever member **84**, by contact between the adjustment screw **94** and the curved surface **96** of the lever member, the range of macro tuning can be finely varied like conventional tuning pegs at the head of an instrument.

Accordingly, the intonation modules provide an increased range of tuning, not previously available, and, in combination with the free-to-vibrate portions **98**, formed by the individual lever-like free-to-vibrate portions, the resonant characteristics of the guitar can be improved to achieve the resonant characteristics of a violin.

In FIGS. **6A–6F**, bridge elements **24A–24F** for each of the individual modules are illustrated. The six strings **6**, each associated with a different one of bridge elements **24** are, starting from the top, E, B, G, D, A and E strings. Though not shown, each of the strings has a different make-up or structure, if a single string is used, the strings have different diameters and, if the strings have a core wire wrapped with a helical wire, the diameter of the strings are different. With different diameters and wire characteristics, the change or elongation of each wire, when it is stretched, is also different. Accordingly, the individual bridge elements **24A–24F** are each shaped differently to accommodate the particular string extending over the bridge element having an enlarged curved surface as compared to the prior art.

Each bridge element **24A–F** has a surface contacted by the string with different large continuously variable radii. First radii extend from the initial second critical point toward the neck of the guitar and the second radii extends from the initial critical point in the opposite direction. The first radius for each of the bridge elements is twice the second radius.

Establishing the radii of the bridge element **24F** as a standard of 1:1, the bridge element **24E** has radii as compared to the bridge element **24F** in the ratio of 1.25:1. In turn, the bridge elements **24D, 24C, 24B** and **24A** have radii ratios as compared to the bridge element **24F**, as follows:

2.40:1, 1.20:1, 2.46:1 and 4.01:1.

As a result, when the fulcrum tremolo or the bridge-tailpiece assembly is pivoted, the tuned characteristics of the strings relative to one another remain the same.

In FIGS. **6G** and **6H** the prior art arrangement is shown, while FIGS. **6I** and **6J** illustrate the present invention. FIGS. **6G** and **6I** display the initial position of the second critical point, and FIGS. **6H** and **6J** exhibit a pivoted position. The fulcrum pivot point is shown to the left of the bridge element by a dot within a circle. In FIG. **6H** the fulcrum tremolo is pivoted to increase string tension and the second critical point and string height drop. The second critical point moves away from the first critical point.

In FIGS. **6I** and **6J** it can be noted that the bridge element has an enlarged curved surface relative to the bridge element in FIGS. **6G** and **6H**. Further the bridge element surface of the present invention has a continuously varied radius. As set forth in FIG. **6J**, when pivoted the bridge element and the second critical point drop for a lesser amount than in FIG. **6H**, the prior art. Moveover, the second critical point moves over the bridge element surface toward the first critical point. Accordingly, the pivoting effect is augmented and with continuously variable enlarged curved surfaces corresponding to the stretch characteristics of the strings, it is possible to maintain relative harmonic tuning between the strings.



The continuously varying curved surfaces afford a smooth transition from the sections on opposite sides of the initial second critical point position.

Depending on the strings a single radius can be provided on the opposite sides of the initial second critical point position.

In providing relatively large variable radii for the bridge elements **24A–F**, a previous problem, that develops in pivoting the assembly downwardly toward the neck **4**, where the strings may contact the surface of the neck or fret board **8**, causing the strings to lose their tuned characteristics, is avoided. A stepped base plate **28** provides means for raising the intonation modules upwardly to match the curved surface of the transverse cross-section of the fret board. Additionally, shims **108**, in combination with the stepped base plate **28**, compensate for differing curvatures of the fret board from instrument to instrument from model to model. The shims **108** each have an elongated slot **110**. The slot permits the shim to be placed between the base plate **28** and the base **82** of the intonation module and to be slid past the downwardly extended block **89** of the base which extends through the opening **78**. By releasing the bolt **89*b***, the shim can be inserted and then secured in place by tightening the bolt.

The stepped base plate **28** is shown with the steps **114** affording increases in height from the outside toward the center of the base plate. If necessary, the combination of the shims **108** and the steps **114** in the base plate **28** can be used to achieve the desired height of the strings above the neck.

When the electric guitar **1** is being played, it may be desirable to prevent any accidental pivotal movement of the tremolo arm. While a variety of different tremolo arm locks or limiters can be used, one embodiment is disclosed in FIGS. **9A** and **7B**. In FIGS. **2, 7A** and **7B**, a tremolo limiter insert **116** is threaded into the wing element **26**. A limiter pin **118** is inserted into the insert **116**. The limiter pin **118** has a head **120** arranged to contact the guitar body, a shank **122** extending through the insert, and a knob **124** on the opposite end of the shank from the head. A compression spring **125** is located between the end of the head **120** connected to the shank **122** and the upper end of the insert **116** through which the shank passes. A thread **126** is formed on the head in engagement with a corresponding thread **127** on the inner surface of the insert. The lower end of the head as viewed in FIGS. **7A** and **7B** is rounded for providing a limited contact area with the guitar body.

In the position shown in FIG. **7A**, the head is in threaded engagement with the insert so that it remains in position preventing the tremolo arm from pivoting so that the bridge-tailpiece assembly cannot pivot.

If the threaded engagement between the head **120** and the insert **116** is released, as shown in FIG. **7B**, the head is retracted into the insert **116** and the tremolo arm **118** and bridge-tailpiece assembly can be pivoted, as desired. An additional thread **127*a*** is located on the head **120** adjacent its free end for holding it in the retracted position, shown in FIG. **7B**.

The spring **125** biases the limiter pin **118** toward the body **3** of the guitar.

In addition to the means for varying the resonance or pitch afforded by the lever-like members of the intonation modules and the wing elements, a set screw, not shown, can be inserted into the free end of the lever member **84**. By varying the depth or position of these set screws within the wing

elements and the lever members, a fine tuning of the pitch of the element or member can be achieved.

In guitars with a "bolt-on" neck design, the neck **4** and body **3** of the guitar are secured together, as shown in FIG. **8A**, note the bolts **132** securing the body and neck together. To raise the string height from the instrument body at the bridge-tailpiece assembly, the flat shim **134** of FIG. **8B** or the wedge shim **136** of FIG. **8C** can be used. As a result, a greater area of the movement is afforded the fulcrum tremolo's upward pitch change for the guitar strings is obtainable and provides for a tighter coupling between the neck and the body.

As mentioned above, a properly adjusted free-to-vibrate portion can be used in a variety of ways to control vibration in different apparatus.

In FIG. **9A**, an engine **140** is illustrated with a free-to-vibrate portion **142** tightly coupled to it for equalizing frequency response. The free-to-vibrate portion has holes **142***a* drilled into it to provide the desired resonant character for preventing the development of vibration which would tend to deteriorate the quality of the sound provided by the microphone or speaker.

FIG. **9B** shows a building frame **240A** with a free-to-vibrate portion **242** tightly coupled to it. The free-to-vibrate portion **242** is connected to a part of the structural frame, such as a beam or column.

The free-to-vibrate portion, as shown in FIGS. **9A–C**, could be used in a variety of different mechanisms or vehicles to prevent the development of undesired vibrations. For instance, the free-to-vibrate portions or tines could be connected to the frame of a helicopter or airplane to control vibration. Such free-to-vibrate portions could be used in bridge structures to control harmonic vibrations. Moreover, the free-to-vibrate portions or tines could be employed in combustion engines, electric motors, plumbing, elevator structures, cam shafts, and other structures subject to harmful vibrations.

The foregoing description has been directed to an electric guitar, however, the basic concept described above with regard to vibration or resonance control can also be achieved in an acoustic guitar.

In FIG. **10A**, an acoustic guitar **150** is shown with a resonance bridge-tailpiece **152**. The guitar has a head **154**, a body **156**, and a neck **158** extending between the body and the head. Strings **160** extend between the head **154** and the bridge **152**.

In FIG. **10B**, a different arrangement of the acoustic guitar is depicted with a resonance bridge, to which the strings are connected, located within the body **156** and with the strings **160** secured to the bridge at anchors **162**. In FIG. **10B**, free-to-vibrate portions of the wing elements **164** are located laterally outwardly from the strings **160**. The portions **164** are shaped or drilled to provide the desired resonance effect, note the holes shown toward the free ends of portions **164**. Other free-to-vibrate portions **180** are aligned with the strings **160**.

In FIGS. **10C** an electric bass guitar **150A** is illustrated with four strings **160A**. It includes a resonance plate **166** coupled to but separate from an existing bridge-tailpiece **168**. The existing bridge-tailpiece **168** fits onto the base **170** of the plate **172** with free-to-vibrate portions **174** located laterally outwardly from the bridge **168**. An adjustment member with an adjustment screw **176**, a spring steel arm **176***a* and a felt pad **176B** is located at a coupled end **178** of each of the groups of three free-to-vibrate portions **174** on the opposite sides of the strings. By adjusting the screw **176**, the spring steel arm **176***a* provides a variably tension pressing the felt pad **176***b* against the free-to-vibrate portions **174** for controlling the degree of vibration, whereby the desired resonance of the free-to-vibrate sections **174** can be achieved. This arrangement provides a mute assembly for the free-to-vibrate portion of the resonance plate.

In FIG. **10B**, a one-piece construction is shown of the acoustic guitar bridge-tailpiece with a resonance plate **166A**. The combined bridge and resonance plate is secured to the body of the guitar. The resonance plate **166A** has two wing elements **164** spaced apart by six differently shaped free-to-vibrate sections **180**. Each of the wing elements **164** and the free-to-vibrate sections **180** are drilled or provided with elongated slots to obtain the desired resonance effect. On the combined bridge and resonance plate, the individual strings are anchored each in alignment with a different one of the free-to-vibrate sections **180**. Each string **160** is secured to a separate anchor **162**.

FIGS. **11A–11D** display a device for tuning or tensioning a string in a stringed musical instrument.

In FIG. **11A**, the end of an instrument neck **204** is shown with six strings **206** all of a different size. The strings pass over a nut **210** and each string is secured by a string tensioning or tuning device **250**. There is a separate device **250** for each of the six strings. Each device **250** is similar.

Each device, as can be noted in FIGS. **11B** and **11C** includes a bracket **252** secured to and projecting from the end of the neck **204**. An L-shaped lever **254** is pivotally connected by a pin **256** to the bracket **252** at the end of the bracket spaced from the neck **204**. The L-shaped lever **254** has a first arm **258** extending generally upwardly from the pivot pin **256** as shown in FIG. **11B**. The other or second arm **260** of the lever extends from the pivot pin **256** toward the end of the neck **204**.

String **206** is secured into a slotted opening **262** in the free end of the first lever arm **258**. A first thumb screw **264** is in threaded engagement with the free end of the first lever arm **258** and secures the string **206** in position. A second thumb screw **264***a* is located on the first arm **258** adjacent the first thumb screws **264** and closer to neck **204**. Second thumb **206** and affords a fine tuning of the string after the coarse tuning by the first thumb screws.

Adjacent the end of the second lever arm **260** spaced from the pivot pin **256** is a forceps-like clamp **266**, also shown in greater detail in FIG. **11D**. The clamp includes a first part **268** secured to the second lever arm **260** and a second part **270** secured to and projecting downwardly from the bracket **252**. As can be seen best in FIG. **11D**, the first part **268** of the clamp has a plurality of serially arranged teeth **272** for interlocking with a corresponding tooth **274** on the second part **270**.

In FIG. **11B** the clamp **266** is closed, securing the string in the locked position. By opening the clamp **266**, as shown in FIG. **11C**, the lever **254** can be pivoted about the pin **256** so that the tension in the string **206** is released. With the plurality of teeth **272** on the first part **268** the inter-engagement of one of the teeth of **272** with the corresponding tooth **274** affords a variable adjustment in the tension acting on the string **206**.

As can be noted in the drawing, the end of the string **206** secured by the first thumb screw **264** is adjacent to the nut **210** so that there is little bending in the string.

The spacing between the teeth **272** is selected so that the difference in tension imparted to the string affords specific pitch changes taking into consideration the stretch characteristics of the string.

While the vibration or resonance control is described above with respect to an electric or an acoustic guitar and to

a microphone or speaker frame, it can be readily appreciated that the use of the basic concept is applicable to a broad range of musical instruments and other apparatus or devices where vibrational control is important for the operation of the musical instrument or of the apparatus or device.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

I claim:

1. A stringed musical instrument comprising an elongated neck and body attached to one end of said neck, a bridge-tailpiece assembly mounted on said body, a plurality of elongated strings, means on said neck for supporting and forming a first critical point for each of said strings, said bridge-tailpiece assembly forming a support and second critical point for each of said strings, said bridge-tailpiece assembly comprising a fulcrum tremolo, said fulcrum tremolo including bearing means mounted on said body and supporting said fulcrum tremolo for pivotal displacement, wherein said bearing means comprises at least one ball bearing member, and a bearing housing adjustably mounted on said body, wherein said ball bearing member is mounted in said bearing housing and a shaft is connected to said fulcrum tremolo, said fulcrum tremolo including means for adjustably mounting said bearing housing on said body for adjustably positioning said bearing housing relative to the body.

2. A stringed musical instrument as set forth in claim 1 wherein said means for adjustably mounting said bearing housing comprises a post threadedly connected to said body and engaged with said bearing housing so that said post is adjustably threaded in said body for adjusting the position of said bearing housing relative to said body.

3. A stringed musical instrument as set forth in claim 2 wherein said post has an annular flange thereon supporting said bearing housing for moving said housing relative to said body.

4. A stringed musical instrument comprising an elongated neck and body attached to one end of said neck, a bridge-tailpiece assembly mounted on said body, a plurality of elongated strings, means on said neck for supporting and forming a first critical point for each of said strings, said bridge-tailpiece assembly forming a support and second critical point for each of said strings, said bridge-tailpiece assembly comprising a fulcrum tremolo, said fulcrum tremolo including bearing means mounted on said body and supporting said fulcrum tremolo for pivotal displacement, wherein said bearing means comprises at least one ball bearing member, said fulcrum tremolo further comprising a plurality of individual adjustable intonation modules mounted on a base plate, each of said intonation modules comprising a base member and a bridge element, each said bridge element having a curved surface for supporting one of said strings at the second critical point, and at least one individual intonation module having an elongated member pivotally connected to said base member and having a passage therethrough for receiving said string supported on said bridge element, said elongated member located on the opposite side of said bridge element from the first critical point.



5. A stringed musical instrument as set forth in claim 4 wherein means are mounted on said base member and in engagement with said elongated member for pivotally displacing said elongated member and varying tension on the string passing through said elongated member.

6. A stringed musical instrument as set forth in claim 5 wherein said means for pivotally displacing said elongated member comprises an adjustment bolt extending in the elongated direction of said elongated member and in threaded engagement with said base member, said adjustment bolt extending through into bearing contact with said surface of said elongated member with said surface extending generally in the elongated direction of said elongated member.

7. A stringed musical instrument as set forth in claim 4 including shim means for one of said intonation modules, said shim means being located between said one intonation module and said base plate for adjusting the vertical displacement of the bridge member relative to the base plate.

8. A stringed musical instrument comprising an elongated neck and a body attached to one end of said neck, a bridge-tailpiece assembly mounted on said body, a plurality of elongated strings, means on said neck for supporting and forming a first critical point for each of said strings, said bridge-tailpiece having a plurality of bridge elements, said plurality of bridge elements each having a surface forming a second critical point for each of said strings, said bridge-tailpiece assembly comprising a fulcrum tremolo having a fulcrum axis, said bridge elements being pivotably displaceable by an essentially constant radius about said fulcrum axis, wherein at least one of said bridge elements has an enlarged curved surface and said enlarged curved surface extending generally in the direction of said strings, said second critical point travels a critical distance along the surface of said enlarged curved surface and displaces the second critical point from said essentially constant radius during the pivoting of said fulcrum tremolo about said fulcrum axis.

9. A stringed musical instrument as set forth in claim 8 wherein said enlarged curved surface has a different radius of curvature on the opposite sides of one position of said second critical point which changes over at least a critical distance sufficient to control the changing of the harmonic tuning of said musical instrument during the pivoting of said fulcrum tremolo device.

10. A stringed musical instrument as set forth in claim 9 wherein said enlarged curved surface has a first end closer to said first critical point and a second end more remote from the first critical point and said enlarged curved surface has a decreasing radius from the first end to the second end thereof.

11. A stringed musical instrument as set forth in claim 9 wherein said enlarged curved surface has a first end closer to said first critical point and a second end more remote from the first critical point and said enlarged curved surface has an increasing radius from the first end to the second end thereof.

12. A stringed musical instrument as set forth in claim 9 wherein each of said strings has a different rate of stretch and said enlarged curved surface varies to compensate for the rate of stretch of at least one of said strings.

* * * * *

EXHIBIT D

# EXHIBIT D

US006891094B2

(12) **United States Patent**
**McCabe**

(10) **Patent No.: US 6,891,094 B2**
(45) **Date of Patent: May 10, 2005**

(54) **TUNING MEANS FOR STRINGED MUSICAL INSTRUMENT**

(75) Inventor: **Geoffrey L. McCabe**, New York, NY (US)

(73) Assignee: **Coherent Sound In Light Inc**, Hollywood, CA (US)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/760,908**

(22) Filed: **Jan. 16, 2001**

(65) **Prior Publication Data**

US 2001/0002570 A1 Jun. 7, 2001

**Related U.S. Application Data**

(60) Continuation of application No. 08/027,729, filed on Jan. 14, 1993, now Pat. No. 6,175,066, which is a division of application No. 07/607,458, filed on Oct. 31, 1990, now Pat. No. 5,198,601.

(51) **Int. Cl.**[7] .......... **G10D 3/14**
(52) **U.S. Cl.** .......... **84/312**; 84/313; 84/298; 84/453
(58) **Field of Search** .......... 84/312 R, 313, 84/314 R, 314 N, 298, 454, 299, 304, 305

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | | |
|---|---|---|---|---|---|
| 4,497,236 | A | * | 2/1985 | Rose | 84/313 |
| 4,512,232 | A | * | 4/1985 | Schaller | 84/313 |
| 4,608,906 | A | * | 9/1986 | Takabayashi | 84/313 |
| 4,611,523 | A | * | 9/1986 | McFarland | 84/313 |
| 4,632,005 | A | * | 12/1986 | Steinberger | 84/313 |
| 4,688,461 | A | * | 8/1987 | Stroh | 84/298 |
| 4,742,750 | A | * | 5/1988 | Storey | 84/313 |
| 5,198,601 | A | * | 3/1993 | McCabe | 84/298 |
| 5,227,571 | A | * | 7/1993 | Cipriani | 84/307 |
| 5,347,905 | A | * | 9/1994 | Cipriani | 84/298 |
| 5,419,227 | A | | 5/1995 | Lavineway | |
| 5,522,297 | A | | 6/1996 | Enserink | |
| 5,537,907 | A | * | 7/1996 | Rose | 84/298 |
| 5,542,330 | A | * | 8/1996 | Borisoff | 84/298 |
| 5,939,653 | A | * | 8/1999 | Chang | 84/313 |

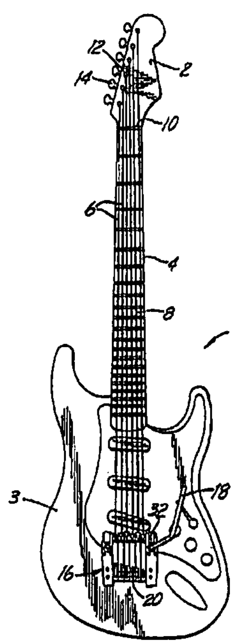
* cited by examiner

*Primary Examiner*—David Martin
(74) *Attorney, Agent, or Firm*—Ivey, Smith and Ramirez; Ellis B. Ramirez

(57) **ABSTRACT**

A stringed musical instrument is provided wherein each string has two critical points, A fulcrum tremolo is mounted on the instrument for varying the tension of the strings and the distance between the two critical points. The strings are attached to a plurality of intonation modules mounted on the fulcrum tremolo. Each intonation module is adjustable so that the strings can be adjusted from an untensioned state to a proper playing pitch. A bearing assembly is also included to facilitate pivoting of the fulcrum tremolo.

**25 Claims, 12 Drawing Sheets**



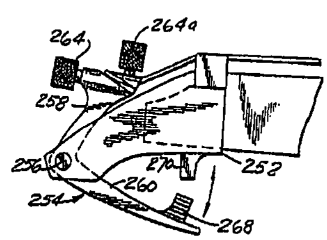
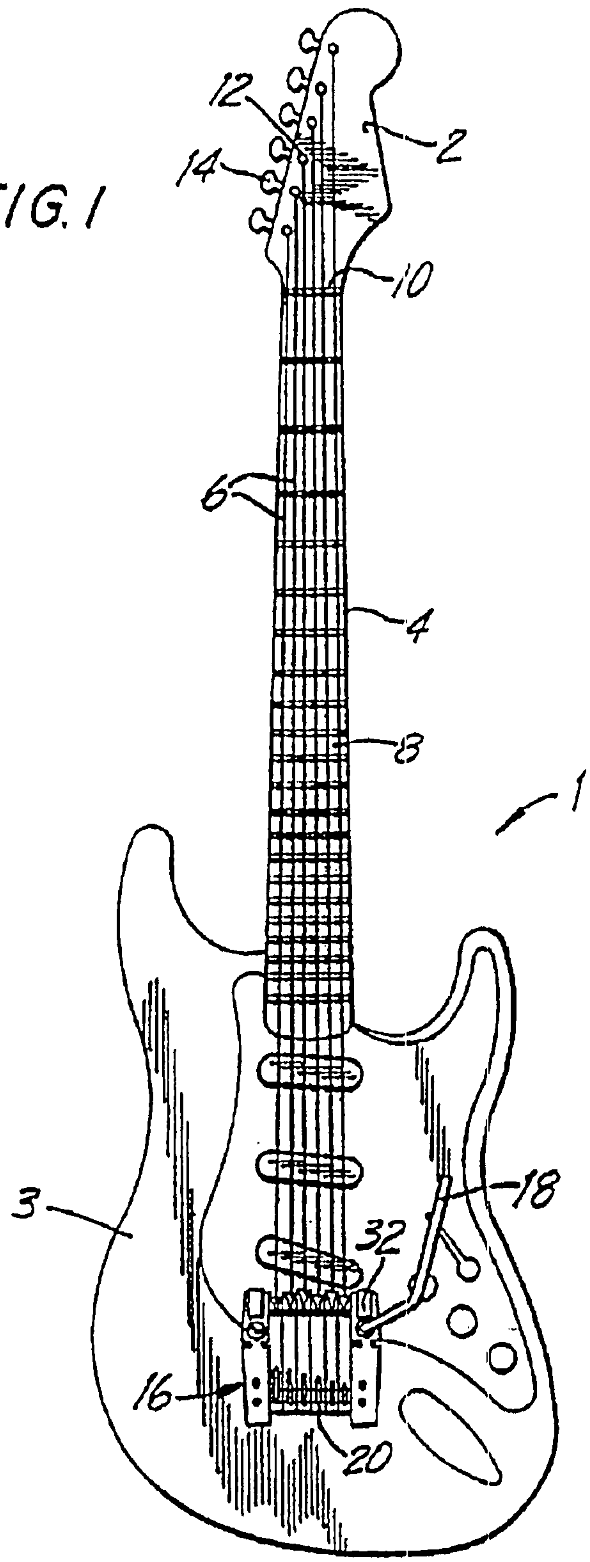



FIG. 1



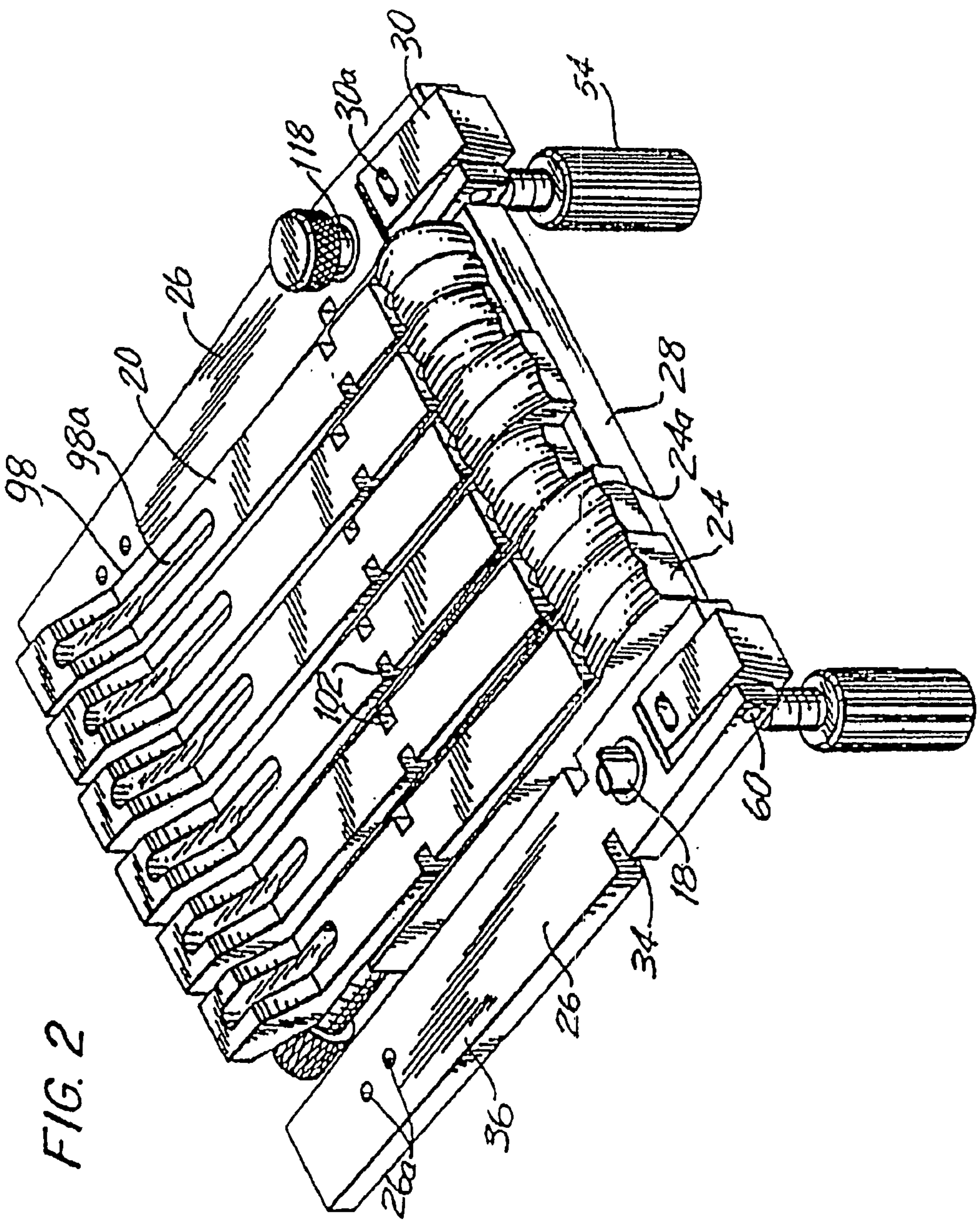
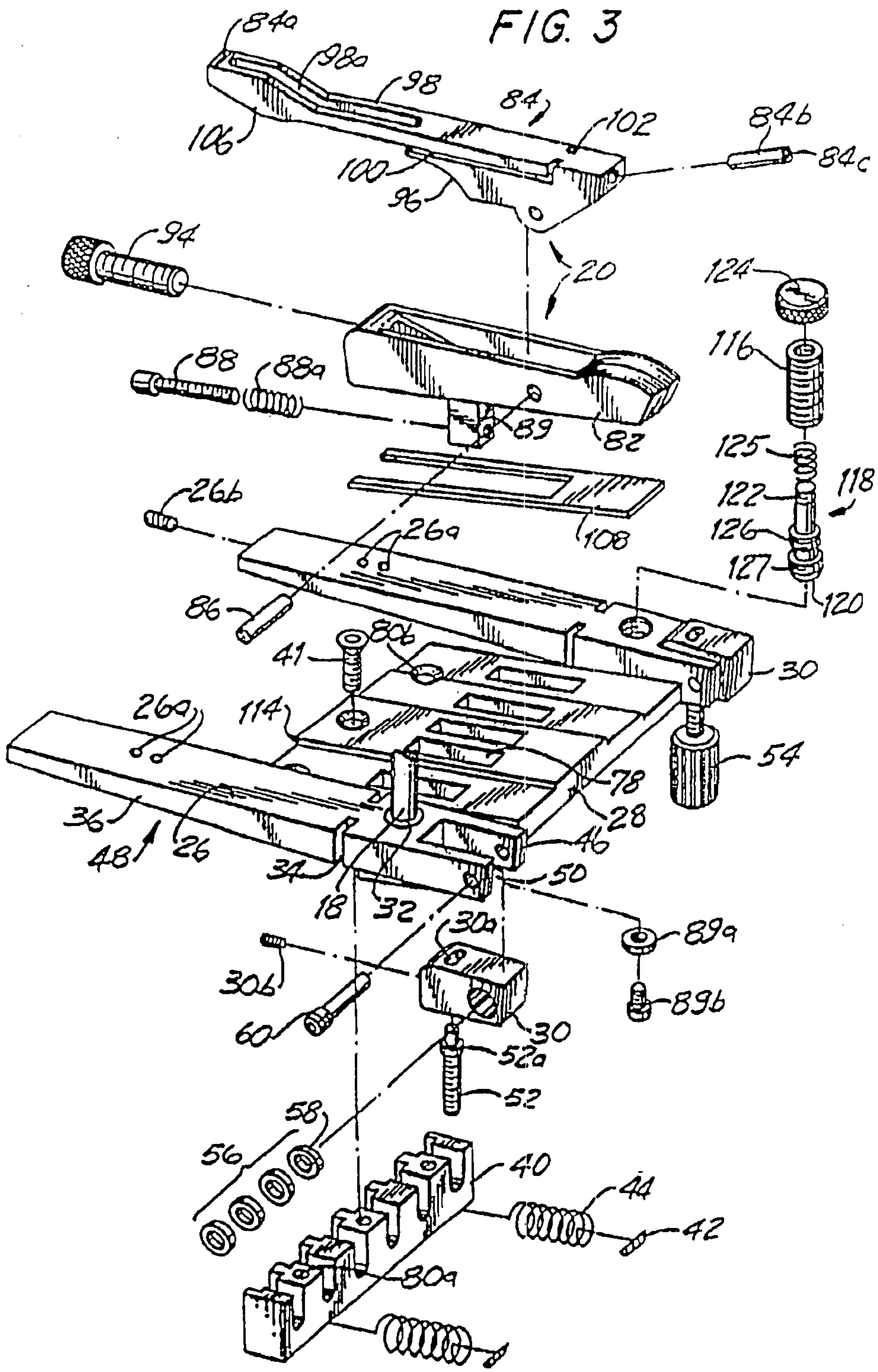



FIG. 2

FIG. 3


84a
98a
98
84
102
84b
84c
106
100
96
94
20
124
116
88
88a
89
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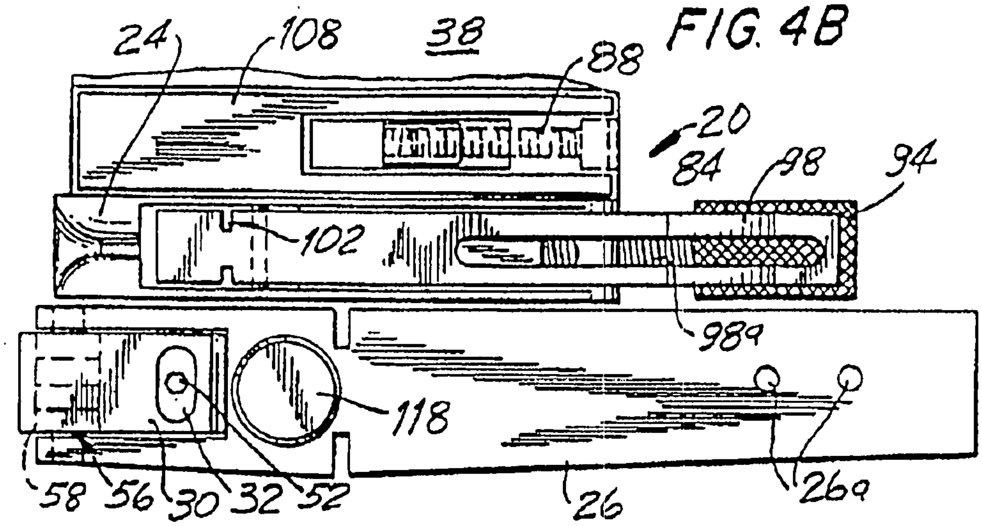
125
122
118
126
127
120
26b
26a
108
86
41
80b
30
26a
114
54
78
28
36
26
48
34
46
50
18
32
30a
89a
30b
89b
60
30
52a
52
58
56
40
44
42
80a

FIG. 4B



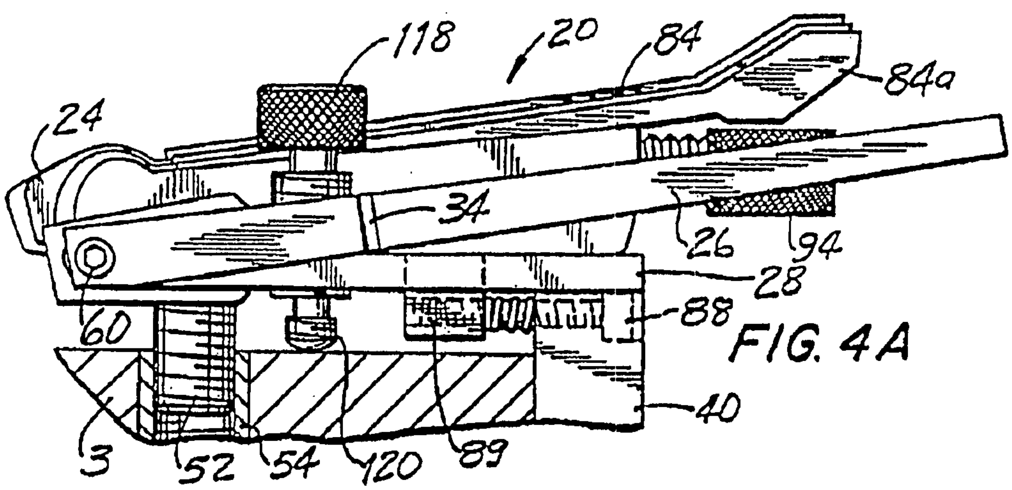




FIG. 4A

FIG. 4C

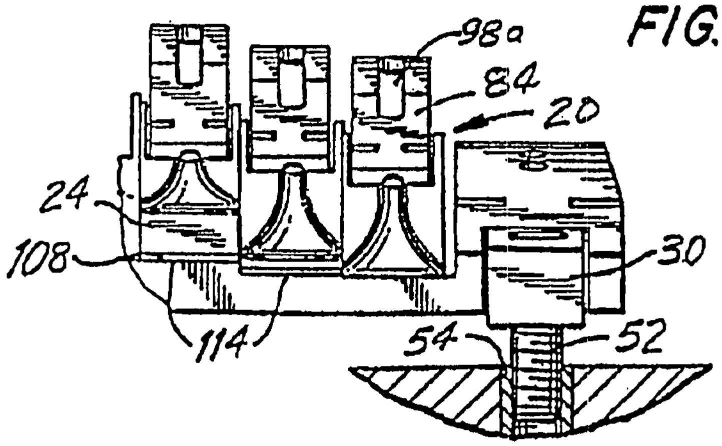


FIG. 5A

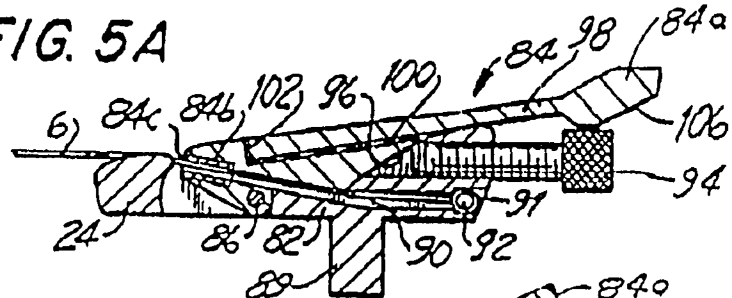



FIG. 5B

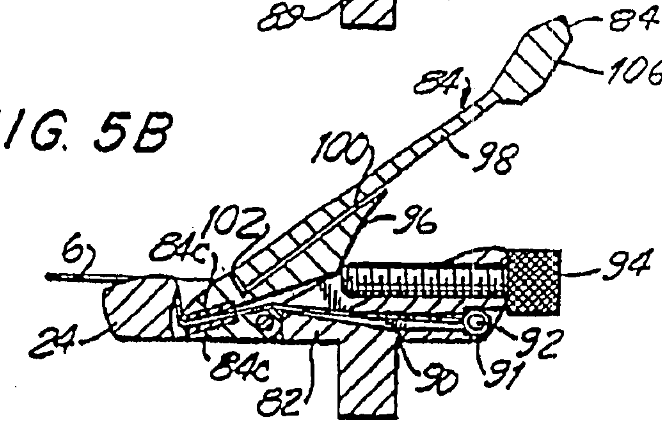



FIG. 7A

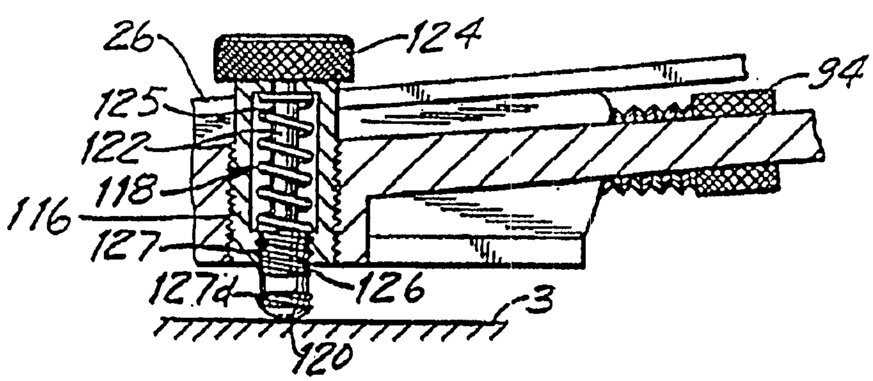



FIG. 7B

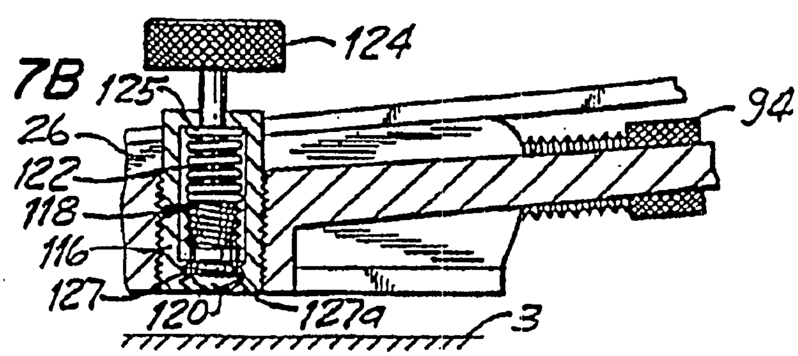


FIG. 6A

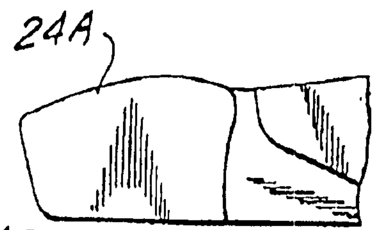



FIG. 6B

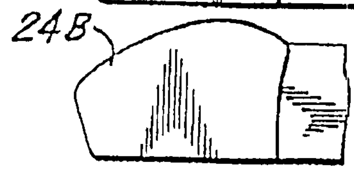



FIG. 6C

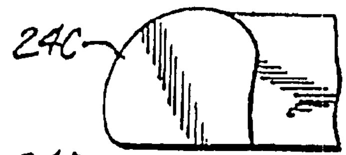



FIG. 6D

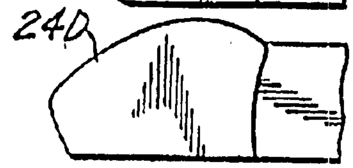



FIG. 6E

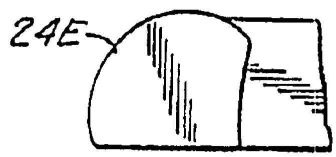
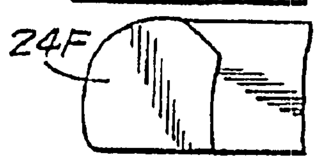



FIG. 6F



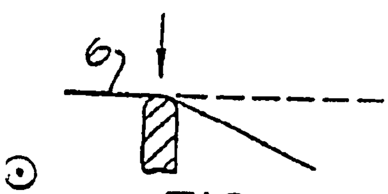




FIG. 6G
PRIOR ART

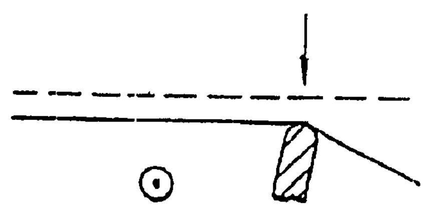


FIG. 6H
PRIOR ART

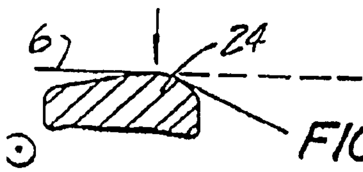



FIG. 6I

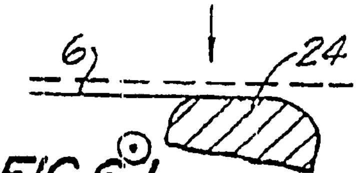



FIG. 6J

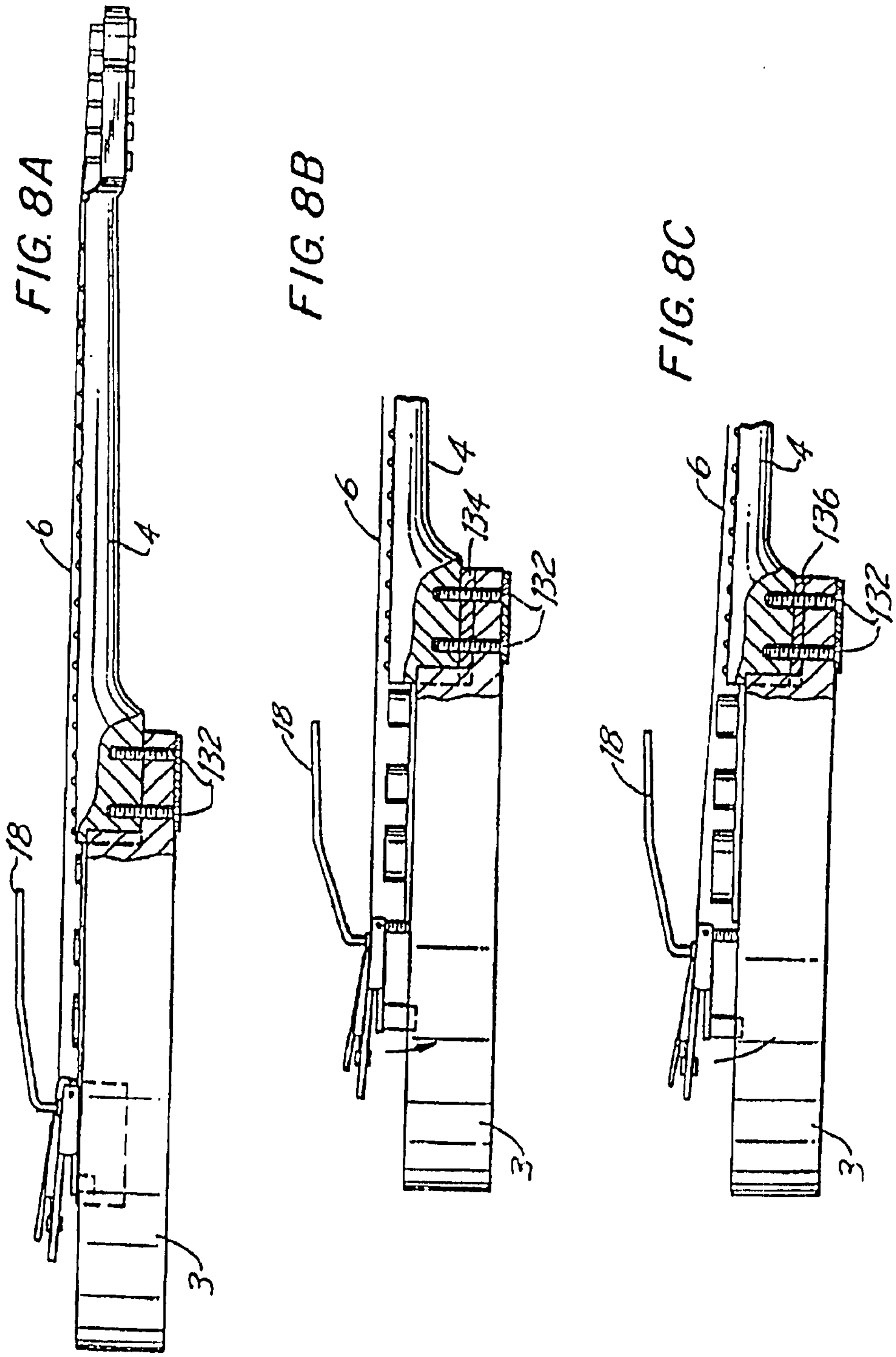


FIG. 8A
FIG. 8B
FIG. 8C
6
4
132
134
136
18
3

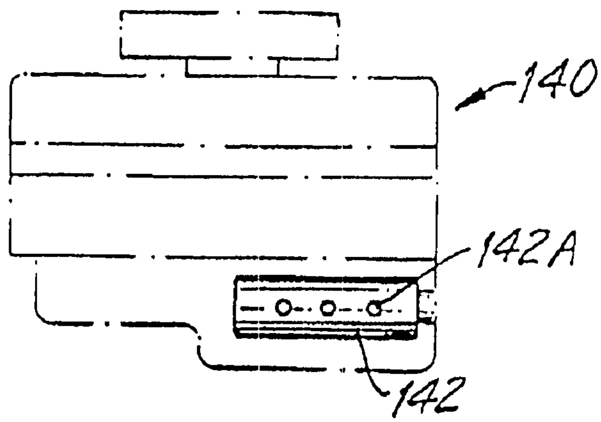
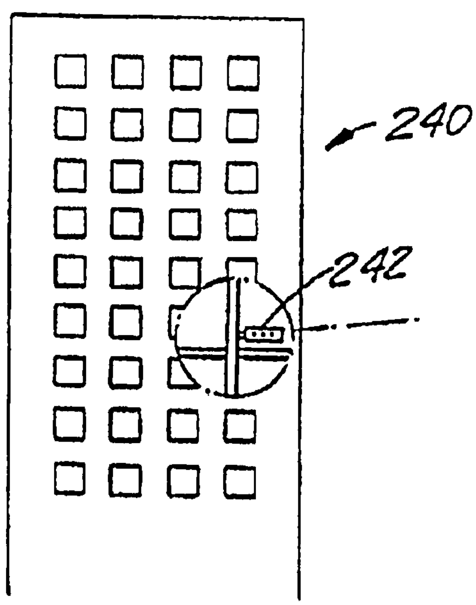



FIG. 9A



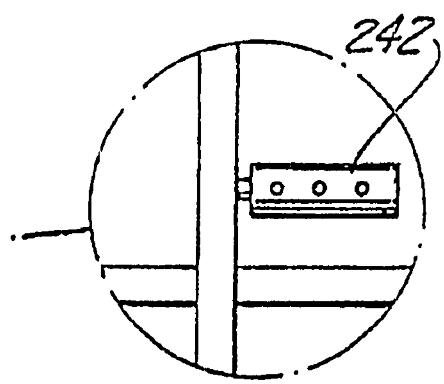




FIG. 9C

FIG. 9B

FIG. 10B-1

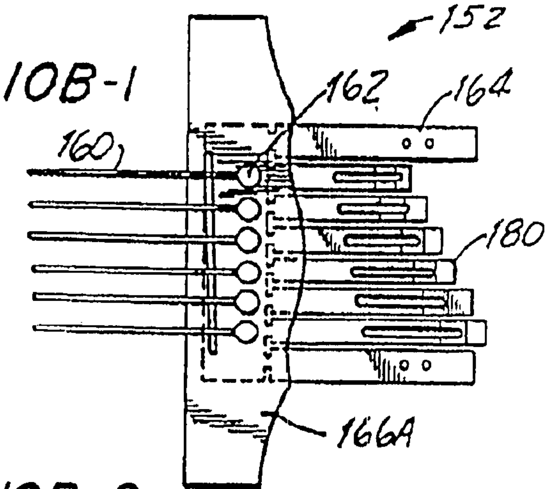



FIG. 10B-2

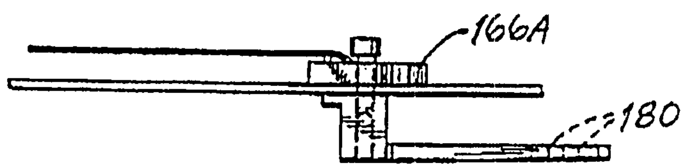



FIG. 10B-3

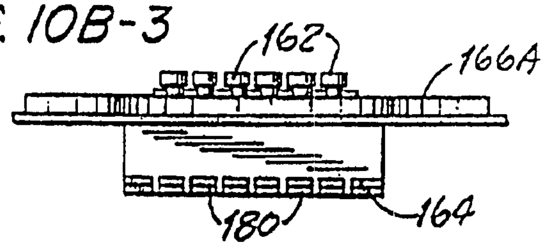
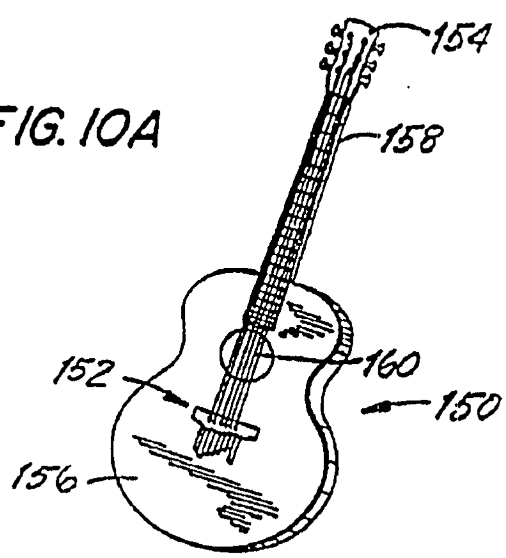



FIG. 10A



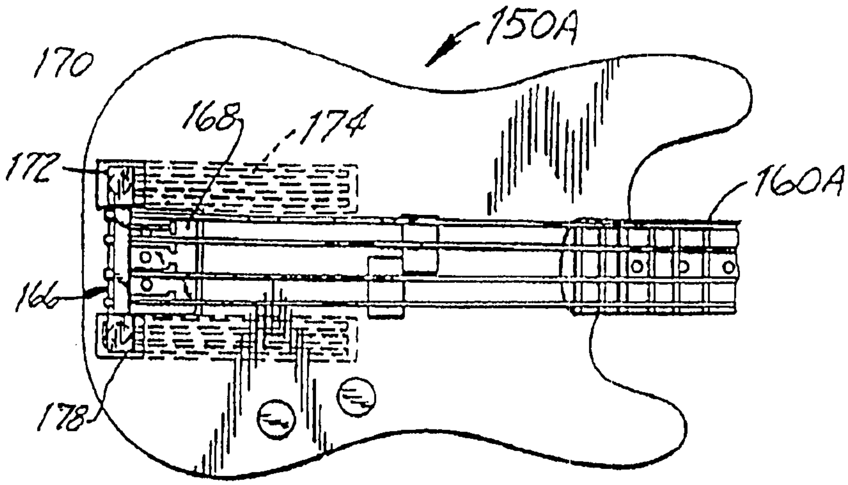



FIG. 10C-1

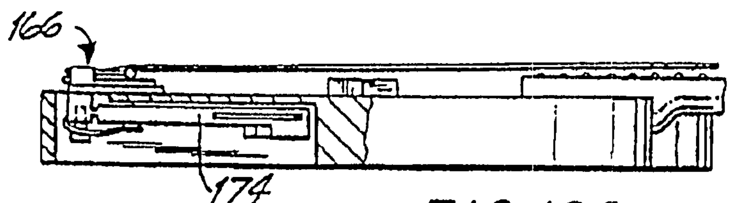



FIG. 10C-2

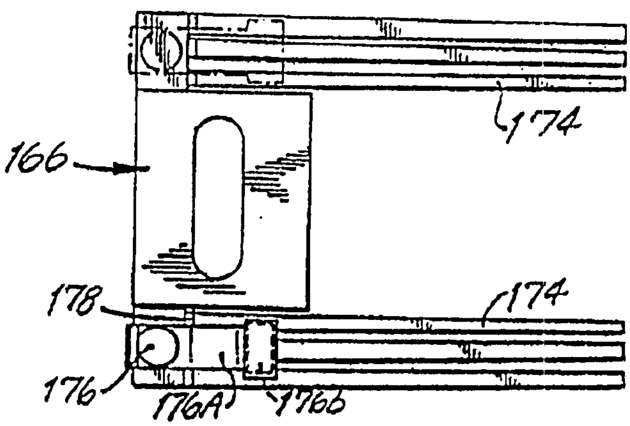



FIG. 10D-1

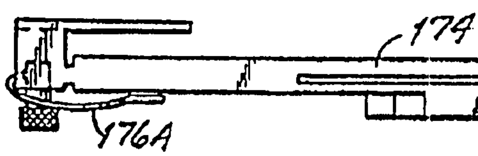



FIG. 10D-2

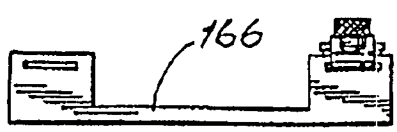



FIG. 10D-3

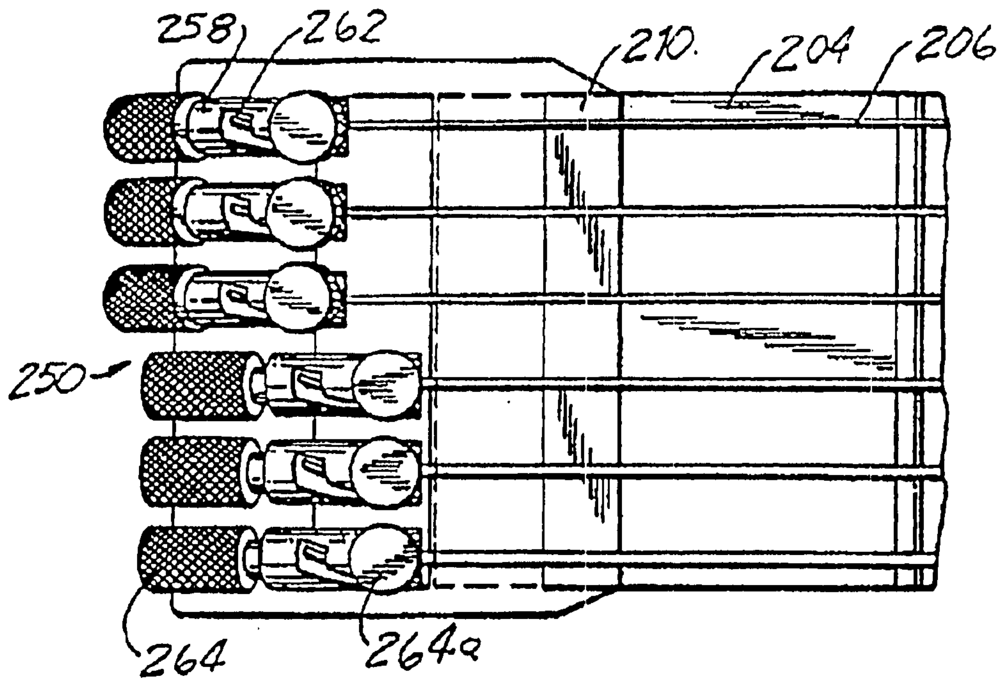



FIG. 11A

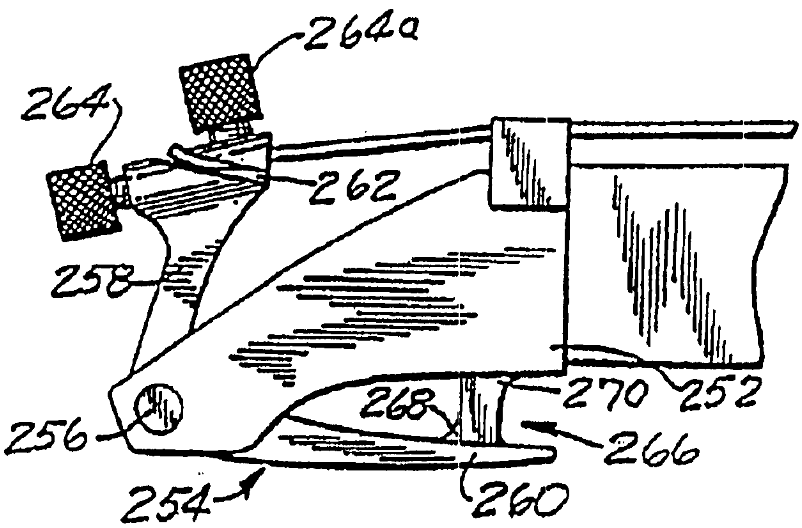



FIG. 11B

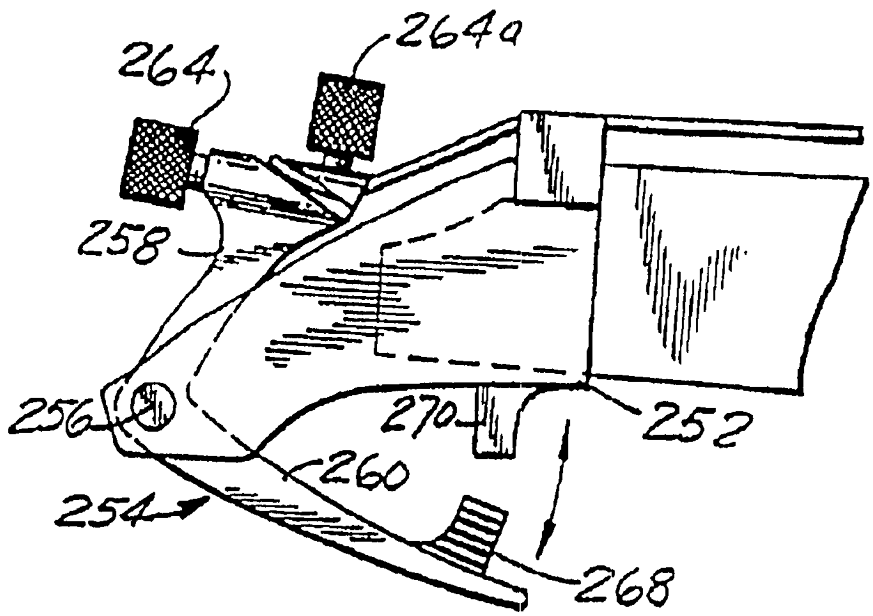



FIG. 11C

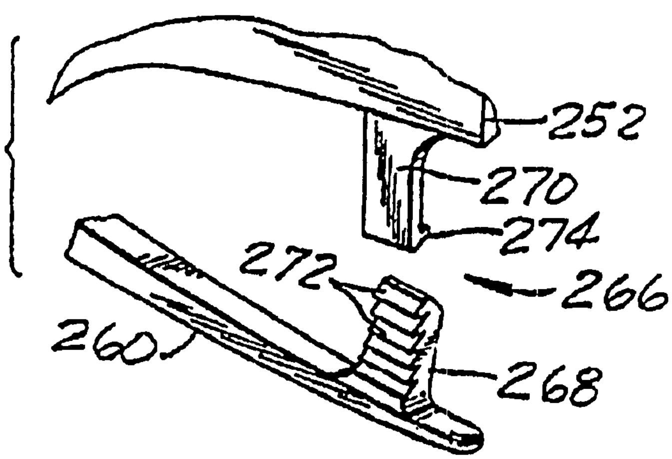



FIG. 11D

# TUNING MEANS FOR STRINGED MUSICAL INSTRUMENT

## RELATED APPLICATIONS

This is a continuation of pending application Ser. No. 08/027,729, filed Jan. 14, 1993, which is a divisional of application Ser. No. 07/607,458, filed Oct. 31, 1990, which issued on Mar. 30, 1993 as U.S. Pat. No. 5,198,601, which are each incorporated by reference as if fully set forth herein.

## BACKGROUND OF THE INVENTION

The present invention is directed to the tuning of a stringed musical instrument, such as a guitar. Further, it is directed to the use of free-to-vibrate parts in such an instrument for reinforcing and enhancing the vibrating characteristics of the instrument.

Basically, a stringed musical instrument is a hollow wooden box serving as a support for a number of strings secured in tension on an outside surface of the box. When the strings are plucked or bowed, they produce complex vibrations transmitted through the bridge or string supports to the wooden box causing its various surfaces to oscillate and setting in motion the air within, and surrounding the box, causing audible sound. Obtaining the desired musical effect can be very difficult. In completely acoustic instruments, as compared to instruments using electronic means for amplification and modifying the tone of the instrument, such as those belonging to the violin family and the folk guitar, the wooden box is constructed to oscillate at a number of determined broad resonances for reinforcing the corresponding range of notes played on the instrument. When the tuning of the instrument is maintained, it will have an apparent increase in volume and sustain and generally will be more pleasing to the ear.

In a stringed musical instrument, such as a guitar, the strings extend unsupported between a first critical point on a neck of the guitar and a second critical point on the guitar body. The first critical point is usually formed by a nut supported in the neck. Generally, the second critical point is formed by a bridge element constituting part of a bridge or a combined bridge and tailpiece assembly. Traditionally, the size of the bridge elements is quite small and functions to clearly define the second critical point and can range from a narrow edge to a rounded surface with a diameter no larger than about 5/32". The strings are typically secured beyond the nut by tuning keys and beyond the bridge element by the tailpiece or tailpiece portion of a bridge and tailpiece assembly. Fine tuning the strings has long been a problem for guitars.

In fine tuning or changing the pitch of a string, two different operations are carried out. In one operation, the length of the string between the first and second critical points is adjusted, such as between the nut and the bridge element, and this is known as harmonic tuning. The second operation involves increasing or decreasing the tension on a given string for raising or lowering the string pitch. This second operation is generally characterized as pitch tuning. In practice, initially harmonic tuning is carried out and then pitch tuning.

A problem existing in tuning the strings is that the two different tuning operations tend to conflict. In harmonic tuning, the pitch is lowered when the distance between the critical points is increased and, conversely, when the distance is shortened, the pitch is raised. In pitch tuning, when the tension is increased, the pitch is raised and when the tension is decreased, the pitch is lowered. These different



operations present difficulties in pitch tuning and maintaining the tuned condition of a stringed musical instrument.

When a fulcrum tremolo is used, there is the tendency when increasing string tension and raising of pitch, also to increase the length of the string, and, conversely, when decreasing string tension and lowering pitch, also to decrease the string length. Accordingly, when using a fulcrum tremolo, these counteracting features are not always balanced.

With the development of the fulcrum tremolo, that is, where the bridge plate is pivoted to provide a tremolo or vibrato effect, the problem of maintaining an effective pivoting action and assuring the return of the bridge plate to an initial position has presented problems. Often, the solution of one problem in pivoting the bridge plate has resulted in the introduction of another problem. As an example, when the bridge plate is pivoted, there is a tendency to upset the harmonic tuning of the strings. Further, the pivot support of the bridge plate, such as disclosed in the Rose U.S. Pat. No. 4,171,661, presented problems in maintaining the proper pivoting action, in returning to the original tuned position, in limiting the range of pivotal movement, and in maintaining the pivot means free from wear. If pivoting of the bridge plate results in wear of the surfaces at which the pivoting action takes place, friction is introduced into the movement of the bridge plate which interferes with its return to the initial position and original tuning.

Combination bridge and tailpiece assemblies have been known for some time. In the Kaufman U.S. Pat. Nos. 1,839,395 and 2,241,911 and in the Beauchamp U.S. Pat. No. 2,152,738, such assemblies were disclosed affording means for varying the tension on the strings and creating a tremolo effect.

In the Proelsdorfer U.S. Pat. No. 2,304,587, string tensioning devices placed on the tailpiece for fine tuning the pitch of the strings of violins, guitars and the like, were disclosed, however, such pitch adjustment is quite limited in range and designed to offer minor adjustment of pitch rather than raising and adjusting from an untensioned condition the strings by the tuners placed on the head of the instrument.

The first fulcrum tremolo combining the bridge and tailpiece was set forth in the Fender U.S. Pat. No. 2,741,146. In this patent, a bevelled ridge portion of the base plate was secured to the instrument body by six screws for permitting limited pivotal movement about the fulcrum and thereby varying the tension on the strings and producing the desired tremolo effect. The strings were supported in the traditional manner on top of the base plate by bridge elements adjustable in height and for string lengths, that is, harmonic tuning. As in known combination bridge and tailpiece assemblies, the strings extend vertically through openings behind the bridge elements and are secured in the tailpiece which in this case also functions to receive the string tensioning biasing springs.

In the Rose U.S. Pat. Nos. 4,171,661 and 4,497,236, two improvements were established. In one improvement, the bevelled ridge portion of the base plate was arranged so that it could be received and held in a tapered slot between the head of the screw and a flanged shoulder, thereby increasing the range of pitch change and improving the return to the initial tuned position and provided for lateral height adjustment of the tremolo. The other improvement involved functionally and physically integrating the bridge elements with the known art of combining fine tuners with anchoring means. In effecting the fine tuning, the bridge elements were provided with a constant radius, so that harmonic tuning

would not be effected when establishing fine tuning, however, fine tuning is limited to a range of about two musical pitches and is inadequate for bringing the strings to proper pitch for compensating string stretch, or achieving common alternate tuning commonly requiring a larger range of pitch change.

In the Shiboya U.S. Pat. No. 4,383,466, a pin was located in a hinge pivot to improve the return to the initial tuned position. This arrangement did not offer lateral height adjustment of the base plate and the field of rotation was not as great as in the Rose improvement.

With these various improvements, a number of problems remained in the known fulcrum tremolo related to the bridge element and its movement when the tremolo is pivoted. Since the second critical point is offset from the pivot axis, initially there is a tendency for the string height at the bridge to decrease when the base plate is pivoted toward the body with the strings contacting the finger board and causing an undesirable buzzing noise and/or deadening the sound of the strings. This phenomenon limits upward pitch change. In addition, there is a tendency for string length to increase when the pitch is raised and for the string length to decrease with the pitch is lowered acting counter to the desired effect. Furthermore, the different diameters and construction of the strings on the instrument cause the strings to stretch at different rates and lose pitch relationship.

Concerning this last problem, several improvements have been proposed in the Steinberger U.S. Pat. No. 4,632,005, the Jones U.S. Pat. No. 3,411,394 and the Hussino U.S. Pat. No. 4,648,304, however, none of them are directed toward the fulcrum tremolo. In the installation of the fulcrum tremolo, there is a problem in routing the cavity to receive the tremolo. At least one routing has been required for the biasing springs. A further problem experienced in guitars and, particularly, in electric guitars is establishing a formant where the various resonances of the instrument co-act with the vibrations of the strings to enhance playing quality. Due to centuries of trial and error in the development of the violin body, a very sophisticated formant has been achieved. This has not been the case for the guitar. Particularly in electric guitars, the wooden box can cause unwanted feedback, so that volume of the cavity in the wooden box is often reduced or completely eliminated, as in the case where a solid body is used. As a result, electric guitars depend greatly on electrical amplification for both volume and tone. In the current design theory of electric guitars, the use of metal and especially of steel bridges contribute such mass that it prevents what little resonances the rest of the instrument possesses from having much effect. Accordingly, the tone of such instruments is limited for the most part by the vibrational characteristics of the strings. Another problem is that some players tend to rest their hand on the fulcrum tremolo while playing and inadvertently move the tremolo and detune the instrument.

In stringed musical instruments, the vibration of the strings in combination with the other parts of the instrument, combine to provide the desired tone or sound of the instrument. In the U.S. Patent to J. D. Webster, U.S. Pat. No. 3,353,433, a tuning fork is incorporated with a floating bridge arrangement. The bridge arrangement depends from the tuning fork and is supported entirely by the strings of the instruments. Accordingly, when the strings are plucked and set into motion the tuning fork is activated and in turn feeds energy back through the bridge arrangement to the strings, the purpose of which is to keep the strings vibrating as long as the tuning fork vibrates. However, the actual pitch and strength or the vibrating of the tuning fork were not adequately considered and the result was unbalanced at best.

In conventional stringed instruments tuning pegs secure the strings at the head of the instrument. The pegs have an opening through which the string is passed and then tied. Problems exist for conventional peg tuning, such as the amount of peg tightening required and the need for adjustment to compensate for on-going tuning and normal string stretch which takes place during use. As a result, fine tuners have been provided on the bridge or tailpiece. Further, often there is a relatively long distance between the nut and the tuning pegs where the string bends causing unequal tension on opposite sides of the nut and tuning problems. One proposed solution employs string clamps on the nut, however as often happens the string stretches beyond the adjustment range of the fine tuners. Accordingly, the required correction is tedious and time consuming involving unclamping, readjusting of the clamp, retuning, reclamping and further readjustment.

## SUMMARY OF THE INVENTION

Therefore, one primary object of the present invention is to provide a stringed musical instrument with an improved arrangement for both harmonic tuning and fine tuning of the instrument.

Another primary object of the invention is to provide a sophisticated set of tuned resonances added to the bridge or the combination bridge and tailpiece assembly of the stringed musical instrument, as a functional analogue to the sophisticated formants found in the violin which improve the sustain and resonant quality of the instrument.

Common objects, such as an odd shaped piece of metal when dropped or struck, and set into vibration, usually have an unpleasant or harsh sound. This is characterized by a low tone referred to as the fundamental which can be one specific frequency or several frequencies defining a broad resonance and higher tones or secondary resonances referred to as harmonics. The irregular mathematical relationship between the frequencies of these tones causes the harsh sound as reflected by the irregular shape of the object.

In the case of a metal bar with parallel sides the tone is more pleasing and by removing mass from the middle of the bar the frequencies of higher tones can be tuned to whole number multiples of the frequency of the lower tone as is done in marimbas and xylophones, and the like.

In another variation, strips of metal tightly coupled at one end to a gourd or a similarly fashioned hollow object comprise the African "thumb piano", however, there has been no effort to tune the upper tones to the lower tones and such metal tines are directed to producing tones for the instrument, like the strings on a guitar for example, and not for the modification of the resonances of the hollow portion, like the body of the stringed instrument such as a violin. It is known that such a bar tightly coupled at one end has two higher tones that are $6.27\times F_1$ (fundamental) and $17.55\times F_1$, respectively. The tuning fork is actually two bars joined together at one end with each vibrating at approximately the same fundamental. When the fork is tightly coupled to another object the second harmonic drops very close to the fundamental and communicates its vibratory character to the object to which it is coupled. Single bars communicate an influence dependant on the ratio of mass between the bar and the object it is coupled to.

As with the bars of the xylophone, changing the shape of the vibrating object tightly coupled at one end creates the means for functionally tuning its resonant frequencies.

The overall length of the free-to-vibrate portion generally defines the frequency of the lowest tone. Transverse slots

can be used to define length. A blind bore in the free end can define the effective length as well.

If the opposite surfaces are tapered toward one another the lowest tones form a broad resonance comprised of many weak frequencies surrounding a strong frequency. Parallel surfaces create one focused low frequency. Removing mass is another way of tuning the higher tones. These recesses can be holes, and when placed close together can form "oval" openings or expanded to slots. Added weight can be used to lower the fundamental resonances whether permanently affixed or adjustable in position.

These means of modifying the character of bars tightly coupled at one end are applicable to changing harmonic content of tuning forks.

A tuning fork or tuning fork-like apparatus of sufficient mass can redefine the resonances of any object to which it is tightly coupled. Additional free-to-vibrate portions of sufficient mass can be tightly coupled to the tuning fork-like apparatus for adding additional resonances. Such a combination can be effective in defining the resonant qualities of any object subject to vibration such as musical instruments.

A further object is to provide individual intonation modules for each string of the instrument affording separate means for the adjustment of harmonic tuning of the bridge portion of the module and macro-tuning of the string attached to the tailpiece portion of the module providing the capacity to bring the strings to proper tension and a tuning range of greater than an octave for use with but not exclusive to "headless" stringed musical instrument, that is, instruments without tuners placed on the head of the instrument.

A further object is to provide two tapered free-to-vibrate portions approximately the same and each with two holes for creating secondary resonances two and three times the strong frequency in the broad resonance and each of approximately the same fundamental resonance tightly coupled to one another and to a musical instrument such that the responsiveness of the musical instrument is defined with no significant resonant peaks or dips other than those created by this tuning fork-like portion.

A further object is that the strong frequency of the tuning fork-like portion is tuned to a pitch of the instrument. For example, it could be a B♭ (B Flat) for a B♭ saxophone or $E_2$ or whole number multiple thereof, specifically for this embodiment designed for guitar.

A further object is that the adjustment of the strong frequencies of the tuning fork-like portion is effected either by a set screw in a blind bore in the free end or by a slidable member.

Yet another object, in addition to the tuning fork-like portion, is to provide six additional tapered free-to-vibrate portions coupled to a musical instrument each with a long slot and a broad resonance of an effective range covering a major third (for example concert C to E on the piano) and which strong frequency is tuned between two pitches, (for example between concert C and D flat on the piano) and which slot creates secondary resonances in whole number multiples of the strong frequency.

A still further object is to provide each of six additional free-to-vibrate portions with a different strong frequency spaced a major third from each other and in concert with the secondary resonances, for reinforcing each note on the instrument in a balanced sensitive and responsive manner. The strong frequency in the broad resonance in the series can be tuned to between 220 hz and 390 hz.

Yet another object of the invention is to provide an improved bearing arrangement for a fulcrum tremolo for assuring the proper and wide range of pivotal movement of the tremolo while limiting wear or friction which would tend to defeat the effectiveness of the tremolo.

Still another object is to provide means for limiting the pivoting of the tremolo towards the body.

An additional object is to provide free-to-vibrate portions for a broad range of devices.

In the description of the invention, the following terms are used and are defined to assure a proper understanding of the terminology employed.

Resonance refers to vibrations of large amplitude within an object subject to vibration, such as a stringed musical instrument. Other instruments or apparatus are also subject to vibration. In the following description of the invention an electric guitar is used as the item subject to vibration however, the invention is also applicable to other vibration instruments and apparatuses.

Resonant frequency is the frequency of an object subject to vibration when set into motion such that it produces a greater response.

Concert tuned pitch is a pitch derived from a commonly accepted standard, for example, A=440 hz.

The musical interval of a major third is the distance of five musical tones, for example, concert C to E on the piano.

Macro-tuners refer to tuners with the capacity to raised and adjust from an untensioned condition strings to proper playing pitch, providing for alternate tunings, and compensation for substantial string stretch during the life of the string essentially without additional means.

Resonant frequencies are the frequencies where the object subject to vibration has more than one mode of vibration.

Fundamental resonant frequency is the lowest resonant frequency in an object subject to vibration.

Secondary resonant frequencies are the frequencies other than the fundamental.

Overtones, or partials, are resonances of various amplitudes above the fundamental resonant frequency.

Coupled is the connection provided between two vibrating objects which influence one another when they are subject to vibration. The coupled condition can be a loose coupling where the resonances of each object remains unchanged or a tight coupling where the resonances of each object interact very strongly.

Hertz is a unit of frequency of a periodic process equal to one cycle per second.

$E_3$ is usually defined as 164.81 hz when $A_4$ is defined as 440 hz by the International Standards Organization; although in Europe and other parts of the world $A_4$ can vary by up to 25 hz. By this standard $B♭_3$ is 233.08 hz, $B_3$ is 246.94 hz, $D_4$ is 293.66 hz and E♭ is 311.13 hz, etc.

Free-to-vibrate refers to a tuned member coupled to another member and having a portion not coupled or in engagement with the other object.

A tuning fork has two tightly coupled free-to-vibrate bars or sections of approximately the same frequency for creating one fundamental resonance frequency with the first harmonic very close to the fundamental and a second harmonic approximately sixteen times the frequency of the fundamental frequency so that no resonant peaks or dips are present between the fundamental resonant frequency and the harmonics. A tuning fork also has the capacity to impart these characteristics to any object to which it is tightly coupled.

A formant is a fixed array of resonances in which the frequency of the harmonics of the object subject to vibration

are emphasized regardless of the fundamental frequency of the vibrational influence on the object.

In a guitar, the strings extend unsupported between a first critical point at the nut mounted in the neck of the guitar and a second critical point at the bridge mounted on the body of the guitar.

In accordance with the present invention, a guitar, preferably an electric guitar, has a body with a neck extending outwardly from the body; usually six strings extend at least from the nut on the neck spaced from the body to some form of anchorage beyond the bridge and mounted on the body. A fulcrum tremolo assembly is mounted over a cavity in the body so that a part of the assembly can be pivoted into the cavity when the tremolo is actuated.

The bridge and tailpiece assembly includes a base plate mounted on the body. The base plate mounts six intonation modules, each arranged to secure one of the strings in its tailpiece portion and to effect the harmonic tuning of the strings. In addition, a wing-like member is located along each of the sides of the base plate, extending in the direction of the strings. Each wing-like member has a first end closer to the neck and a second end more remote from the neck. Adjacent the first end, the wing-like member is directly connected or tightly coupled to the base plate. The wing-like member has a section extending in the direction of the strings from the connected part, away from the neck. The wing-like section has a lower surface facing the body and the lower surface can be tapered upwardly to the rearward free end of the section. The wing-like members are located laterally outwardly from the cavity in the body. Because of their shape, when the bridge plate is pivoted, the wing-like members do not interfere with the pivoting action and do not contact the surface of the body In the intonation modules the bridge element is functionally separate and physically distanced from the tailpiece portion.

At the connected first end of the wing-like members, the base plate is pivotally supported in a bearing assembly containing ball bearings adjustably mounted so that the plate can be variably spaced from the surface of the body. The bearing assembly includes a self-aligning means to accommodate the variable adjustment of the base plate. Further, instead of at the sides, it is possible to locate the pivot point or pivot axis for the base plate along the front side of the plate facing toward the neck.

Also by using self-aligning bearings or a bearing affording a universal joint type movement, it is possible effectively to pivotally support the base plate, when its axis is not parallel with the surface of the body.

As compared with the knife-edge pivot support of the fulcrum tremolo disclosed in the Rose U.S. Pat. No. 4,171,661, it is possible to limit the wear of the bearing so that unnecessary friction is not developed which would interfere with the return of the base plate to its initial position. In its initial position, the base plate is fine tuned. When the tremolo is pivoted to provide a vibrato effect, the tension on the strings is increased or decreased. When the tremolo arm is released, the tremolo should return to its initial position so that its fine tuned condition is maintained. If the bearing arrangement for the base plate should prevent its return to the initial position, then further adjustment would be needed. In accordance with the present invention, however, ball bearings assure that the bridge assembly returns to the initial position and that wear does not take place which would interfere with the pivotal movement, and of offers a greater field of rotation for the largest possible pitch change.

Existing acoustic physics indicates when two vibrating objects are "tightly" coupled, the resonances of one will influence the resonances of the other. A free-to-vibrate portion of an object set into motion will adopt a resonant frequency and resonances defined primarily by its length and mass. The addition or reduction of mass and its subsequent location along a defined length will change the pitch of the resonant frequency and resonances. Accordingly, the resonant frequency and resonances of an object can be changed based on the characteristics of the free-to-vibrate portion of the other object. As a result, by selecting the structure of the free-to-vibrate portion, it is possible to adjust resonant frequencies in objects subject to vibration.

The control of vibrations has a broad application, not only in musical instruments, such as stringed instruments, but also in speakers and microphones. Moreover, for creating less conflicting energy, such as in engines for vehicles such as motor cars. The control of vibrations can be employed in any device subject to vibration, particularly where the vibrations may tend to have a deleterious effect.

The use of free-to-vibrate portions or elements has preferred application in musical instruments, especially stringed musical instruments.

Musical instruments have tuned resonances for augmenting the energy of a vibrating source. In stringed instruments, a hollow box, usually a wooden box, serves as a support for a number of strings maintained under tension. The box is designed so that its surfaces oscillate producing vibrations in the air within and surrounding it, so that the sound of the vibrating strings are amplified and audible. The oscillating surfaces are arranged to have resonances for reinforcing the vibrations of the strings. In accordance with the present invention, the various parts of the bridge and tailpiece assembly are arranged to enhance the vibrations of the strings.

Various parts of a stringed musical instrument can be selectively configured so as to be free-to-vibrate for augmenting the vibration of the strings, that is, to amplify the energy of the strings. In a preferred embodiment, the free-to-vibrate portions are particularly effective when coupled with the strings or with the bridge elements.

In electric stringed musical instruments, such as electric guitars, the body, which in some instances may not be hollow, does not contribute substantially to the amplification of the instrument. In such instruments, the bridge does not function to transfer the energy of the vibrating string to the body for amplification, rather it reflects the energy back to the string where it is picked up by an electromagnetic device and amplified electronically. However the use of the bridge for establishing resonances can be most effective when coupling of various free-to-vibrate portions create resonances for reinforcing the vibration of the strings in a manner analogous to the reinforcing effect of a hollow body in a purely acoustic instrument. Since the over-all tonal character of any instrument is effected by the choice of materials, size and shape, and other structural features, the resulting pattern of resonances, its "formant" can be adjusted by these various features to reinforce or modify the sound of the instrument to suit a player's needs.

Free-to-vibrate portions can be a part of the wing-like members on the base plate, a part of the intonation modules mounted on the base plate, part of the structure of the base plate, or other parts connected to the instrument.

The free-to-vibrate portion can be shaped to provide the requisite fundamental resonant frequency. The shape of the free-to-vibrate portion can be a tapered member with the tapering surface being planar or curved. Moreover, weights can be added to the free-to-vibrate portion or mass removed

for tuning the fundamental resonant frequency to provide the desired effect. It is also possible, where the free-to-vibrate portion affords its use, to mount a slidable member securable by a set screw on the portion for varying the frequency.

While free-to-vibrate portions can be used for effecting a formant in a stringed musical instrument, such parts can also be employed for controlling the vibration of other objects, such as an automobile engine or even a building or other large structure. In the operation of an automobile engine, or of many other mechanical devices, it is possible for vibrations to develop which have a deleterious effect on the continued operation of the device. By providing the proper free-to-vibrate portions on a vibrating device, the range of vibrations can be kept within certain limits or tuned for limiting or avoiding damage.

A significant feature of the use of the free-to-vibrate portion is that it is tightly coupled to the vibrating object for achieving the desired result. As pointed out above, the wing-like member forming the free-to-vibrate portion, is formed integrally with the base plate. Without the tightly coupled connection, the influence of the free-to-vibrate portion is not achieved.

Another preferred feature of the invention is the arrangement of the intonation modules on the base plate for providing harmonic and pitch tuning of the individual strings and also for influencing the vibration of the strings by incorporating free-to-vibrate portions as a part of the intonation modules.

The intonation modules are slidably mounted in slots in the base plate for effecting the desired harmonic tuning, that is, for fixing the string length between the first and second critical points. Each intonation module can be separately locked in position establishing the desired length between the critical points.

The second critical point is formed by a bridge element constructed as a part of the intonation module, though it is functionally separate from the rest of the module. The bridge element is connected to a base elongated in the direction of the strings. The base is slidably connected to the base plate and is secured to the base plate after the harmonic tuning is effected. The intonation module base has a front or first end on which the bridge element is formed and it extends away from the bridge element toward the rear end of the body, that is, the opposite end from the neck. The bridge element forms the second critical point. An important feature of the bridge element is its varied curved surface contacted by the string.

A significant feature of the invention is the manner in which the curved surface is formed. In the initial position of the tremolo, the second critical point divides the curved surface into a first section closer to the neck and a second section more remote from the neck. When the base plate is pivoted, the intonation modules and, as a result, the bridge elements pivot with it so that the location of the second critical point changes, increasing or decreasing the tension on the strings. Since the strings each have a different cross-sectional size, there is a variable tensioning effect on the strings. To maintain the fine tuned character of the strings relative to one another, each of the enlarged curved surfaces of the bridge elements are varied relative to one another so that each of the second critical points travels along the surface in differing distances and thereby selectively changing the harmonic tuning. By providing the proper ratio between each of the enlarged curved surfaces on each of the bridge elements, it is possible to compensate for uneven string stretch and maintain the relative harmonic tuning between the strings during the pivoting movement of the



tremolo. Furthermore, by increasing the radius of the first section relative to the radius of the second section the upward pitch change can be further augmented. Lastly, by varying the radii continuously a smooth transition from the first section to the second section can be achieved.

Another important feature of the invention is the increase radial size of the bridge elements for maintaining the string height relative to the fingerboard when the tremolo is used. Accordingly, the bridge elements cannot contain rotatable parts since harmonic tuning would be disturbed in the initial position. Consequently, the bridge elements must be functionally separate from the tailpiece. Further, the strings must slide over the bridge elements during change of tension in the fine tuning.

Another object of the invention compared to the prior art is to provide a shortened spring-block or the base plate, moved rearwardly and fitted with smaller string tension biasing springs, so that the whole assembly can be fitted into a single cavity in the body of the instrument below the base plate. This feature simplifies routing of the body.

Still another object of the invention is to provide a stepped base plate and shims for adjusting the height of the bridge elements and for maintaining tight coupling between the bridge elements and the base plate.

Each intonation module has a lever-like time member pivotally connected to the base adjacent the bridge element, with the tine member extending from the pivot point toward the rear end of the guitar body. A passage is provided through the tine member for receiving the string after it passes over the bridge element, with the string being anchored at the rear end of the passage in the tailpiece part. By pivoting the tine member, the tension on the string can be varied. The pivoting of the lever-like tine member, can be effected by an adjustment member mounted on the base.] The tine member has a curved surface extending toward the rear end of the body. The adjustment member can be threaded into the base and into contact with the curved surface and such contact causes the lever-like tine member to pivot about its connection to the base. As a result, the orientation of the passage through the lever-like member can be altered so that:the tension of the string passing through it is also changed. Further, the forward tips of the lever-like tine pivot under the bridge element for dramatically increasing the potential of the tension effected by the adjustment member. Accordingly, macro-tuning of the individual strings can be achieved by the adjustment member.

It is also possible to form a rear part of the lever-like member as a free-to-vibrate portion for adding resonances to the bridge and tailpiece assembly. The free-to-vibrate portion of the lever-like tine member can be shaped to provide the desired fundamental resonant frequency. The combination of the free-to-vibrate portions on the base plate and in the intonation modules provide a formant in the instrument.

The base plate is formed of a first part extending generally parallel to the surface of the guitar body and a second part disposed perpendicular to the rear end of the first part and extending downwardly from it into the recess in the body. The second part is connected to spring means within the cavity for effecting the return of the tremolo or bridge assembly into the initial position after the tremolo has been pivoted and released.

The tremolo is pivoted by a tremolo arm secured to one wing-like member of the base plate. An insert is formed in the wing-like member into which the tremolo arm can fit.

To avoid accidental displacement of the tremolo arm, a releasable lock secures it in its initial position until the tremolo arm is to be intentionally pivoted.

Still another significant feature of the invention is the creation of a sophisticated set of tuned resonances in the bridge or the bridge and tailpiece assembly of a stringed musical instrument. In one preferred embodiment, means are provided for creating a formant in the vibration of the guitar as it is played. The desired effect can be achieved by using tapered free-to-vibrate portions tightly coupled to the bridge or bridge and tailpiece assembly. With at least two tapered free-to-vibrate portions each having a broad resonance and a strong central resonance frequency adopting characteristics of a tuning fork, the second harmonic drops from approximately six times the fundamental to within a few Hertz of the fundamental removing any other resonant peaks or dips, other than the third harmonic which relatively is not influential for the bridge mass, since this tuning fork-like apparatus vibrates for an extended period it will keep its secondary resonances created by two cylindrical holes in each tapered free-to-vibrate portion and any other free-to-vibrate portion coupled thereto vibrating and active.

In addition, six other free-to-vibrate portions or tine members are arranged as part of the intonation modules, each tuned to have a broad resonance with its own harmonics or secondary resonances. When secondary resonances from any two or more tine members are placed close to one another harmonically, they simulate the effect of a fundamental broad resonance. By properly tuning the tine members, the tuning fork portions, and their secondary resonances, a formant is established, fully reinforcing the vibrations of any note played on the instrument in a balanced manner and providing exceptional volume, tone and sustain as in great violins.

Since the free-to-vibrate portions are tuned to react with a wide range of frequencies, they act like sensitive antennae vibrating sympathetically to the sound produced by the speakers in the electric amplification means. This increased sensitivity allows for outstanding sustain with lower amplifier distortion at lower playing volumes than would be otherwise possible.

Aluminum alloys are particularly effective in forming the free-to-vibrate portions and afford greater sensitivity than other materials. Stainless steel can also be used for any of the parts of the bridge, or bridge and tailpiece assembly, due to their ability to couple extremely well. Further, stainless steel is relatively free from wear.

Although the invention is described with respect to metal guitar bridges and more specifically fulcrum tremolos, it is equally possible to create free-to-vibrate portions out of wood or synthetic materials such as reinforced graphite, especially for use in purely or semi-acoustic instruments.

Choice of materials in the construction of musical instruments has always been important. As scientific advances and new developments in materials continue to evolve at a brisk rate, their application can be directed to the use of free-to-vibrate portions coupled to musical instruments.

The use of steel, brass and bronze is very common in musical instruments and steel has become the favored material for stringed musical instrument bridges, because of its bright sound, great mass and durability. Accordingly, steel is a suitable material for the present invention, however, for the first time aluminum can be utilized as it shares the same stiffness to mass ratio as steel but will afford a softer sounding, more responsive and resonant response and, depending on the player, may be preferred.

Further, recent advances in ceramics have been outstanding and have produced entire automobile engines. Commercial applications of ceramics are becoming increasingly common in everyday life, for example, reasonably priced bells and knives are available where steel has been replaced by ceramic materials. As ceramics are more readily moldable and offer acoustic properties similar to steel, they can be used for all bridge parts from the intonation module base to the free-to-vibrate portions.



In some applications, particularly those directed toward non-electric or purely acoustic instruments, other materials may be desirable. Certainly, wood is the most obvious choice, throughout history its superior qualities have been demonstrated. Plastics and composites, such as graphite epoxy, have been used successfully to create sound boards for guitars and violins where the mechanical properties of a composite sandwich plate with graphite-epoxy facings and a low density core closely matched those of a conventional spruce plate. Such materials could be used effectively and economically to produce high quality free-to-vibrate resonant plates and bridges of a consistent level.

Another primary object of the present invention is to provide an adjustment device for bringing the strings to pitch at one of several coarse tunings quickly and then fine tuned by separate means.

A tuning adjustment device is provided for securing the string at the head of the instrument and then making a fine tuning adjustment by means of a thumb screw. The tuning device is pivoted on the head end of the stringed instrument and is movable between several tensioned positions and a untensioned or released position. In the tension position the anchorage for the string is located relatively close to the nut at the head end of the instrument so that little bending of the string takes place.

The tuning device is formed as a two armed L-shaped lever pivotally mounted on a bracket secured to the head end of the instrument in the region of the nut. The string is secured at a free end of one arm of the lever and a locking means for the device is provided adjacent the free end of the other lever arm. The locking means is in the form of a forceps-like clamp containing a plurality of teeth so that each tooth provides a different locking position. By changing the locking position the tension on the string can be quickly increased or decreased as required for providing preset pitch changes.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a plan view of an electric guitar embodying the present invention;

FIG. 2 is a perspective view of a tremolo-bridge-tailpiece assembly as used in the guitar of FIG. 1;

FIG. 3 is an exploded perspective view of the tremolo-bridge-tailpiece assembly in FIG. 2;

FIG. 4A is a side view of the bridge-tailpiece assembly of FIG. 2;

FIG. 4B is a partial plan view of the bridge-tailpiece assembly of FIG. 3A;

FIG. 4C is a partial end view of the bridge-tailpiece assembly of FIG. 3A;

FIGS. 5A and 5B are side views illustrating the range of displacement of a lever member in the intonation module;

FIGS. 6A–F are cross-sectional views of the different bridge elements mounted on the intonation modules as shown in FIG. 1 and FIG. 2;

FIGS. 6G and 6H are schematic illustrations of a bridge element showing the prior art;

FIGS. 6I and 6J are schematic illustrations of the bridge elements of the present invention;

FIG. 7A is a side view, partly in section, of a retractable tremolo limiter in a limiting position;

FIG. 7B is a side view, similar to FIG. 7A, however, showing the tremolo free to pivot;

FIG. 8A is a partial side view of a guitar with a "bolt-on" neck;

FIG. 8B is a view similar to FIG. 8A with a flat shim;

FIG. 8C is a view similar to FIG. 8B with a wedge shim;

FIG. 9A is a side view of an engine with an attached free-to-vibrate section;

FIG. 9B is a view of a building frame with a free-to-vibrate portion;

FIG. 9C is an enlarged detail view of the encircled part in FIG. 9C;

FIG. 10A is a perspective view of an acoustic guitar with a resonance bridge;

FIG. 10B is an enlarged partial plan view of the acoustic guitar and resonance bridge;

FIG. 10C is a side view of the acoustic guitar and resonance plate;

FIG. 10D is a plan view of the resonance plate separate from the bridge;

FIG. 11A is a plan view of a plurality of adjustment tuning devices for use on a stringed instrument;

FIG. 11B is a side view of one of the devices shown with the string in the tensioned position;

FIG. 11C is a side view, similar to FIG. 11B, however, with the string in the unlocked or released position; and

FIG. 11D is a detailed view, on an enlarged scale, of a locking means for the device.

## DETAILED DESCRIPTION OF THE INVENTION

In FIG. 1, an electric guitar 1 is illustrated comprising a head 2 at one end, a body 3 at the other end, with a neck 4 extending between the head and the body. Six strings 6 extend from the head 2 to the body 3 over the neck 4. The neck 4 forms a fret board 8 for the guitar. At the head, each of the strings extends over a nut 10 forming the first critical point for the strings. The nut 10 is located at the transition from the neck 4 to the head 2. Each of the strings 6 is anchored on the head by an anchor 12 and each anchor has a corresponding tuner or tuning peg 14. On the body 3, the strings 6 are secured to a bridge-tailpiece assembly 16. The bridge-tailpiece assembly is a fulcrum tremolo with an arm 18 for pivoting the fulcrum tremolo and providing a vibrato effect on the strings. The bridge-tailpiece assembly 16 includes six intonation modules 20.

In the body 3 of the guitar there are electric pick-ups.

In the following description, the bridge-tailpiece assembly 16 will be described in greater detail.

The bridge-tailpiece assembly 16 forms a second critical point for the strings 6, sometimes characterized as an intonation point or bridge point.



In FIG. 2, the bridge-tailpiece assembly 16 or fulcrum tremolo is shown on an enlarged scale as compared to FIG. 1. FIG. 3 displays the bridge-tailpiece assembly 16 of FIG. 2 in an exploded view. The second critical point is located at the front end of the assembly 16 extending across the bridge elements 24. There is a separate bridge element 24 for each of the intonation modules 20. Outwardly from the intonation modules 20 on each side of the opposite sides extending in the string direction, there are two wing elements 26. The wing elements 26 are formed integrally with a main stepped plate 28. Each of the wing elements 26 is supported on a bearing housing 30. The bearing housings 30 pivotally support the stepped base bridge plate 28. The tremolo arm 18, shown only in part, is secured within an arm insert 32 and pivots the assembly 16 relative, to the bearing housings 30.

Each wing element 26 is secured integrally with the main bridge plate 28 in the region of the bearing housing 30 and the arm insert 32. Immediately behind the arm insert 32 are slits 34 extending transversely of the long direction of the wing elements, that is, transversely of the direction of the strings 6, and partially separating a free-to-vibrate portion 36, from the portion of the wing element 26 secured to the stepped base plate 28.

As can be seen in FIG. 9, the body 3 has a routed opening 38 located below the bridge-tailpiece assembly 16, with a spring block 40 secured by bolts 41 to the stepped base plate 28 and extending downwardly from it, into the routed opening 38. A spring plate 42, shown only schematically, is secured within the routed opening 38 below the stepped base plate and spaced slightly rearwardly from the bridge elements 24. Springs 44 extend between the spring plate 42 and the spring block 40 for returning the bridge-tailpiece assembly 16 back to its original position, after it has been pivoted by the tremolo arm 18.

The wing elements 26 extend generally parallel with the intonation modules 20 and with the strings 6. Each wing element 26 is pivotally supported by its bearing housing 30. The forward portion 46 of the wing element 26, located closer to the neck 4, is formed integrally with the stepped base plate 28.

The forward portion 46 of the wing element 26 is fairly massive, while the rearward portion 48 tapers from the forward portion, separated partly from it by slits 34, into a relatively thin section forming the free-to-vibrate portion 36. Transverse to the string direction, the wing elements 26 are relatively wide, being somewhat wider than the intonation modules 20. The rearward portion 48 or free-to-vibrate portion 36 is separated from the stepped base plate 28.

The free-to-vibrate portion 36 is shaped to provide the desired resonance for enhancing the vibration of the strings and improving the tone of the guitar. The free-to-vibrate portion 36 can have curved or tapered surfaces. In addition to the shape of the free-to-vibrate portion, the desired resonance characteristic can be achieved by drilling single or multiple holes 26*a* in the portion, and by adding mass to or removing mass from the portion 36. The holes 26*a* can be joined together to form elongated slots intermediate the ends of the free-to-vibrate portion or extending from the free end toward the coupled end. In FIG. 3 a set screw 26*b* is inserted into a threaded hole, not shown, for fine tuning the pitch of the free-to-vibrate portion.

In FIGS. 2, 3 and 4A–4C, the bearing housing 30 is shown at the forward end of the wing element 26. The bearing housing 30 fits into a cut-out 50 in the forward end of the wing element 26. The housing 30 is adjustably supported

relative to the body 3 of the guitar by a threaded post 52 with annular flange 52*a*. Post 52 is threaded into a housing insert 54 in the body 3 of the guitar, note FIGS. 4A and 4C. By adjusting the extent of the threaded engagement for the post 52 into the body insert 54, the spacing between the body 30 and the surface of the body 3 is selectively adjustable. Adjustment of the post 52 is effected through an oval opening 30*a* in the top of the housing 30. The oval shape permits relative movement between the post 52 and the housing 30. A set screw 30*b* fits into the rear end of the housing 30 to secure the post 52. In the housing 30, forwardly of the post 52, there is an opening through the housing extending transversely of the string direction of the guitar containing a quad-stack bearing assembly 56, formed by four side-by-side roller bearings 58. A pin or shaft 60 is threaded into one side of the wing element 26 and extends through the bearings 58 into the wing element on the opposite side of the recess 50. Accordingly, by manipulating the tremolo arm 18, the bridge-tailpiece assembly 16 or fulcrum tremolo can be pivoted about the pin 60 to achieve the desired effect when playing the guitar.

While a quad-stack bearing assembly 56 is shown for pivotally supporting the bridge-tailpiece assembly 16, a variety of pivot bearings could be employed. A significant feature is that the bearing assembly permits the displacement of the bridge-tailpiece assembly with the pivot axes of the pins 60 not parallel to the surface of the body 3. This feature is important when the bearing housings 30 on the opposite sides of the bridge-tailpiece assembly each have a different height above the body surface of the guitar.

As shown in FIG. 3, the sleeve-like arm insert 32 is threadably secured in the forward portion 46 of the wing element. The arm 18 is threadably secured in the insert. By means of the arm, the bridge tailpiece assembly 16 is pivoted.

In FIG. 3, the main bridge plate 28 is shown with the attached wing elements 26. Note that the free-to-vibrate portions 36 are separate from the main bridge plate and are partially separated from the forward portion 46 by the slits 34. The main bridge plate 28 includes the spring black 40 located at the rearward end of the plate, that is, the end more remote from the neck of the guitar.

Approximately in line transversely of the string direction with the insert 32, are six rectangular openings 78, note FIG. 3. Each of these openings receives a projection 89 of each of the intonation modules 20 to be described later.

In FIG. 3, a portion of the tremolo arm 18 is shown extending upwardly from the insert 32 for effecting the pivoting action of the bridge-tailpiece assembly 16. The spring block 40 is provided with screw holes 80*a* aligned with screw holes 80*b* in the base plate 28 to receive bolts 41 for securing the block to the plate. The springs 44 are secured to and extend between the spring plate 42 and the spring block 40. The springs 44 return the bridge-tailpiece assembly 16 to its original position after the tremolo arm 18 is released following pivotal displacement of the assembly.

In FIG. 3, one of the intonation modules 20 is shown, including a base 82 with a bridge element 24 located on the right hand end of the base. A lever member 84 is pivoted to the base by a pivot pin 86. The base 82 is adjustably secured to the spring block 40 of base plate 28 of the bridge-tailpiece assembly 16 by a bolt 88 and spring 88*a*. The bolt 88 is supported in the spring block 40 and is threaded into projection 89 on the base 82 extending through an opening 78. Spring 88*a* encircles the bolt 88 between the block 40 and the projection 89. By turning the bolt 88 the position of



the intonation module relative to the base plate 28 can be adjusted. As can be seen in FIG. 2, the openings 78 are elongated in the string direction and permit adjustment of the intonation module in that direction for effecting harmonic tuning. The positions of individual intonation modules can be adjusted by turning the bolts 88. The projecting 89 is secured at the under side of the base plate 28 by a washer 89*a* and a bolt 89*b* threadably secured and into the underside of the base 82.

The bridge element 24 has a recessed variably curved portion 24*a*, note FIG. 3, in which the corresponding string 6 seats as it moves over the bridge element. From its point of contact with the bridge element 24, that is, at the second critical point, the string 6 moves downwardly into an elongated passageway 90 extending first through lever member 84 and then through the base 82 from adjacent and just rearwardly of the bridge element 24 to the rearward end of the base, note FIGS. 5A and 5B. At the front end of the lever member 84, at the entrance into the passageway 90 there is a stainless steel sleeve 84*b* which forms a wear resistant surface for the strings 6. At the rearward end of the passageway 90, an enlarged recess 91 in the base 82 is provided for an anchor 92 securing the ball end of the string 6.

An adjustment screw 94 is threaded into the rearward end of the base 82 into engagement with a surface 96 of the lever member 84. In FIG. 5A, the adjustment screw 94 contacts the surface 96 so that the string 6 is in contact with the surface 96 at its intersection with the passageway 90. This position is the rearwardmost point of contact of the string within the passageway 90 with the lever member 84.

In FIG. 5B, the maximum range of upward displacement of the lever member 84 is shown. As the lever member 84 is pivoted upwardly by threading the adjustment screw 94 forwardly into the base 82, the sleeve 84*b* in the forward end of the passageway 90, that is, the forward end of the lever member 84, contacts the string 6 and presses it downwardly providing an adjustment in the pitch tuning of the string by varying the tension or pull exerted on the string. The contact of the string 6 with the surface of the corresponding bridge element 24 is also varied. As the adjustment screw 94 is moved between the two limiting positions, shown in FIGS. 5A and 5B, the tension on the string 6 is varied.

The lever member 84 has a free-to-vibrate portion 98 formed by a slit 100 in the lever member extending in the string direction from a rearward part of the surface 96 to a point approximately above the pivot pin 86. Slits 102 extending transversely of the slit 100 pass through the lever member connecting the slit 100 with the upper surface of the lever member. The slits 102 can be seen in FIGS. 2, 3, 5A and 5B. The free-to-vibrate section 98 of the lever member 84 extends from the slits 102 to the rearward end of the lever member 84 where the free end 84*a* is enlarged to form a mass 106 for obtaining the desired resonance effect for the lever member. Slots 98*a* can be formed in the broad surface of the free-to-vibrate section 98 of the lever member 84 for achieving the desired resonance effect.

While only a single intonation module is illustrated in FIGS. 3, 5A and 5B, the lever members 84 for each of the intonation modules can be selectively shaped to afford the desired resonance effect for the whole bridge tailpiece assembly. The combination of the resonance effects of the lever members 84 added to the resonance effects of the tuning fork-like tapered wing elements 26 provides a formant for the guitar not previously attainable.

In the bridge-tailpiece assembly 16, the tailpiece afforded by the rearward end of the base 82 of each intonation module

**20** is functionally separated from the bridge element **24** located on the forward end of the corresponding intonation module.

In the past, any adjustment available in the bridge-tailpiece assembly has been limited to fine tuning, usually less than a range of three pitches where the octave has twelve pitches. With the adjustment screws **94** of each intonation module **20**, it is possible to obtain macro tuning where the range extends over a full octave creating a means to bring from an untensioned condition of the string to proper playing pitch. With this arrangement, it is possible to eliminate the tuning pegs at the opposite end of the guitar and provide what has been characterized as a "headless" guitar. With the range of displacement of the lever member **84**, by contact between the adjustment screw **94** and the curved surface **96** of the lever member, the range of macro tuning can be finely varied like conventional tuning pegs at the head of an instrument.

Accordingly, the intonation modules provide an increased range of tuning, not previously available, and, in combination with the free-to-vibrate portions **98**, formed by the individual lever-like free-to-vibrate portions, the resonant characteristics of the guitar can be improved to achieve the resonant characteristics of a violin.

In FIGS. **6A–6F**, bridge elements **24A–24F** for each of the individual modules are illustrated. The six strings **6**, each associated with a different one of bridge elements **24** are, starting from the top, E, B, G, D, A and E strings. Though not shown, each of the strings has a different make-up or structure, if a single string is used, the strings have different diameters and, if the strings have a core wire wrapped with a helical wire, the diameter of the strings are different. With different diameters and wire characteristics, the change or elongation of each wire, when it is stretched, is also different. Accordingly, the individual bridge elements **24A–24F** are each shaped differently to accommodate the particular string extending over the bridge element having an enlarged curved surface as compared to the prior art.

Each bridge element **24A–F** has a surface contacted by the string with different large continuously variable radii. First radii extend from the initial second critical point toward the neck of the guitar and the second radii extends from the initial critical point in the opposite direction. The first radius for each of the bridge elements is twice the second radius.

Establishing the radii of the bridge element **24F** as a standard of 1:1, the bridge element **24E** has radii as compared to the bridge element **24F** in the ratio of 1.25:1. In turn, the bridge elements **24D**, **24C**, **24B** and **24A** have radii ratios as compared to the bridge element **24F**, as follows:

2.40:1, 1.20:1, 2.46:1 and 4.01:1.

As a result, when the fulcrum tremolo or the bridge-tailpiece assembly is pivoted, the tuned characteristics of the strings relative to one another remain the same.

In FIGS. **6G** and **6H** the prior art arrangement is shown, while FIGS. **6I** and **6J** illustrate the present invention. FIGS. **6G** and **6I** display the initial position of the second critical point, and FIGS. **6H** and **6J** exhibit a pivoted position. The fulcrum pivot point is shown to the left of the bridge element by a dot within a circle. In FIG. **6H** the fulcrum tremolo is pivoted to increase string tension and the second critical point and string height drop. The second critical point moves away from the first critical point.

In FIGS. **6I** and **6J** it can be noted that the bridge element has an enlarged curved surface relative to the bridge element in FIGS. **6G** and **6H**. Further the bridge element surface of the present invention has a continuously varied radius. As set forth in FIG. **6J**, when pivoted the bridge element and the second critical point drop for a lesser amount than in FIG. **6H**, the prior art. Moreover, the second critical point moves over the bridge element surface toward the first critical point. Accordingly, the pivoting effect is augmented and with continuously variable enlarged curved surfaces corresponding to the stretch characteristics of the strings, it is possible to maintain relative harmonic tuning between the strings.

The continuously varying curved surfaces afford a smooth transition from the sections on opposite sides of the initial second critical point position.

Depending on the strings a single radius can be provided on the opposite sides of the initial second critical point position.

In providing relatively large variable radii for the bridge elements **24A–F**, a previous problem, that develops in pivoting the assembly downwardly toward the neck **4**, where the strings may contact the surface of the neck or fret board **8**, causing the strings to lose their tuned characteristics, is avoided. A stepped base plate **28** provides means for raising the intonation modules upwardly to match the curved surface of the transverse cross-section of the fret board. Additionally, shims **108**, in combination with the stepped base plate **28**, compensate for differing curvatures of the fret board from instrument to instrument from model to model. The shims **108** each have an elongated slot **110**. The slot permits the shim to be placed between the base plate **28** and the base **82** of the intonation module and to be slid past the downwardly extended block **89** of the base which extends through the opening **78**. By releasing the bolt **89*b***, the shim can be inserted and then secured in place by tightening the bolt.

The stepped base plate **28** is shown with the steps **114** affording increases in height from the outside toward the center of the base plate. If necessary, the combination of the shims **108** and the steps **114** in the base plate **28** can be used to achieve the desired height of the strings above the neck.

When the electric guitar **1** is being played, it may be desirable to prevent any accidental pivotal movement of the tremolo arm. While a variety of different tremolo arm locks or limiters can be used, one embodiment is disclosed in FIGS. **9A** and **7B**. In FIGS. **2**, **7A** and **7B**, a tremolo limiter insert **116** is threaded into the wing element **26**. A limiter pin **118** is inserted into the insert **116**. The limiter pin **118** has a head **120** arranged to contact the guitar body, a shank **122** extending through the insert, and a knob **124** on the opposite end of the shank from the head. A compression spring **125** is located between the end of the head **120** connected to the shank **122** and the upper end of the insert **116** through which the shank passes. A thread **126** is formed on the head in engagement with a corresponding thread **127** on the inner surface of the insert. The lower end of the head as viewed in FIGS. **7A** and **7B** is rounded for providing a limited contact area with the guitar body.

In the position shown in FIG. **7A**, the head is in threaded engagement with the insert so that it remains in position preventing the tremolo arm from pivoting so that the bridge-tailpiece assembly cannot pivot.

If the threaded engagement between the head **120** and the insert **116** is released, as shown in FIG. **7B**, the head is retracted into the insert **116** and the tremolo arm **118** and bridge-tailpiece assembly can be pivoted, as desired. An additional thread **127*a*** is located on the head **120** adjacent its free end for holding it in the retracted position, shown in FIG. **7B**.

The spring **125** biases the limiter pin **118** toward the body **3** of the guitar.

In addition to the means for varying the resonance or pitch afforded by the lever-like members of the intonation modules and the wing elements, a set screw, not shown, can be inserted into the free end of the lever member **84**. By varying the depth or position of these set screws within the wing elements and the lever members, a fine tuning of the pitch of the element or member can be achieved.

In guitars with a "bolt-on" neck design, the neck **4** and body **3** of the guitar are secured together, as shown in FIG. **8A**, note the bolts **132** securing the body and neck together. To raise the string height from the instrument body at the bridge-tailpiece assembly, the flat shim **134** of FIG. **8B** or the wedge shim **136** of FIG. **8C** can be used. As a result, a greater area of the movement is afforded the fulcrum tremolo's upward pitch change for the guitar strings is obtainable and provides for a tighter coupling between the neck and the body.

As mentioned above, a properly adjusted free-to-vibrate portion can be used in a variety of ways to control vibration in different apparatus.

In FIG. 9A, an engine **140** is illustrated with a free-to-vibrate portion **142** tightly coupled to it for equalizing frequency response. The free-to-vibrate portion has holes **142*a*** drilled into it to provide the desired resonant character for preventing the development of vibration which would tend to deteriorate the quality of the sound provided by the microphone or speaker.

FIG. 9B shows a building frame **240A** with a free-to-vibrate portion **242** tightly coupled to it. The free-to-vibrate portion **242** is connected to a part of the structural frame, such as a beam or column.

The free-to-vibrate portion, as shown in FIGS. 9A–C, could be used in a variety of different mechanisms or vehicles to prevent the development of undesired vibrations. For instance, the free-to-vibrate portions or tines could be connected to the frame of a helicopter or airplane to control vibration. Such free-to-vibrate portions could be used in bridge structures to control harmonic vibrations. Moreover, the free-to-vibrate portions or tines could be employed in combustion engines, electric motors, plumbing, elevator structures, cam shafts, and other structures subject to harmful vibrations.

The foregoing description has been directed to an electric guitar, however, the basic concept described above with regard to vibration or resonance control can also be achieved in an acoustic guitar.

In FIG. **10A**, an acoustic guitar **150** is shown with a resonance bridge-tailpiece **152**. The guitar has a head **154**, a body **156**, and a neck **158** extending between the body and the head. Strings **160** extend between the head **154** and the bridge **152**.

In FIG. **10B**, a different arrangement of the acoustic guitar is depicted with a resonance bridge, to which the strings are connected, located within the body **156** and with the strings **160** secured to the bridge at anchors **162**. In FIG. **10B**, free-to-vibrate portions of the wing elements **164** are located laterally outwardly from the strings **160**. The portions **164** are shaped or drilled to provide the desired resonance effect, note the holes shown toward the free ends of portions **164**. Other free-to-vibrate portions **180** are aligned with the strings **160**.

In FIG. **10C** an electric bass guitar **150A** is illustrated with four strings **160A**. It includes a resonance plate **166** coupled to but separate from an existing bridge-tailpiece **168**. The existing bridge-tailpiece **168** fits onto the base **170** of the



plate **172** with free-to-vibrate portions **174** located laterally outwardly from the bridge **168**. An adjustment member with an adjustment screw **176**, a spring steel arm **176*a*** and a felt pad **176B** is located at a coupled end **178** of each of the groups of three free-to-vibrate portions **174** on the opposite sides of the strings. By adjusting the screw **176**, the spring steel arm **176*a*** provides a variably tension pressing the felt pad **176*b*** against the free-to-vibrate portions **174** for controlling the degree of vibration, whereby the desired resonance of the free-to-vibrate sections **174** can be achieved. This arrangement provides a mute assembly for the free-to-vibrate portion of the resonance plate.

In FIG. **10B**, a one-piece construction is shown of the acoustic guitar bridge-tailpiece with a resonance plate **166A**. The combined bridge and resonance plate is secured to the body of the guitar. The resonance plate **166A** has two wing elements **164** spaced apart by six differently shaped free-to-vibrate sections **180**. Each of the wing elements **164** and the free-to-vibrate sections **180** are drilled or provided with elongated slots to obtain the desired resonance effect. On the combined bridge and resonance plate, the individual strings are anchored each in alignment with a different one of the free-to-vibrate sections **180**. Each string **160** is secured to a separate anchor **162**.

FIGS. **11A–11D** display a device for tuning or tensioning a string in a stringed musical instrument.

In FIG. **11A**, the end of an instrument neck **204** is shown with six strings **206** all of a different size. The strings pass over a nut **210** and each string is secured by a string tensioning or tuning device **250**. There is a separate device **250** for each of the six strings. Each device **250** is similar.

Each device, as can be noted in FIGS. **11B** and **11C** includes a bracket **252** secured to and projecting from the end of the neck **204**. An L-shaped lever **254** is pivotally connected by a pin **256** to the bracket **252** at the end of the bracket spaced from the neck **204**. The L-shaped lever **254** has a first arm **258** extending generally upwardly from the pivot pin **256** as shown in FIG. **11B**. The other or second arm **260** of the lever extends from the pivot pin **256** toward the end of the neck **204**.

String **206** is secured into a slotted opening **262** in the free end of the first lever arm **258**. A first thumb screw **264** is in threaded engagement with the free end of the first lever arm **258** and secures the string **206** in position. A second thumb screw **264*a*** is located on the first arm **258** adjacent the first thumb screws **264** and closer to neck **204**. Second thumb **206** and affords a fine tuning of the string after the coarse tuning by the first thumb screws.

Adjacent the end of the second lever arm **260** spaced from the pivot pin **256** is a forceps-like clamp **266**, also shown in greater detail in FIG. **11D**. The clamp includes a first part **268** secured to the second lever arm **260** and a second part **270** secured to and projecting downwardly from the bracket **252**. As can be seen best in FIG. **11D**, the first part **268** of the clamp has a plurality of serially arranged teeth **272** for interlocking with a corresponding tooth **274** on the second part **270**.

In FIG. **11B** the clamp **266** is closed, securing the string in the locked position. By opening the clamp **266**, as shown in FIG. **11C**, the lever **254** can be pivoted about the pin **256** so that the tension in the string **206** is released. With the plurality of teeth **272** on the first part **268** the inter-engagement of one of the teeth of **272** with the corresponding tooth **274** affords a variable adjustment in the tension acting on the string **206**.

As can be noted in the drawing, the end of the string **206** secured by the first thumb screw **264** is adjacent to the nut **210** so that there is little bending in the string.

The spacing between the teeth **272** is selected so that the difference in tension imparted to the string affords specific pitch changes taking into consideration the stretch characteristics of the string.

While the vibration or resonance control is described above with respect to an electric or an acoustic guitar and to a microphone or speaker frame, it can be readily appreciated that the use of the basic concept is applicable to a broad range of musical instruments and other apparatus or devices where vibrational control is important for the operation of the musical instrument or of the apparatus or device.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. A stringed musical instrument comprising:

a body,

a neck extending outwardly from said body,

a head located opposite said body on said neck,

at least one string extending from said body to said head, said at least one string having a first end and a second end,

a first mechanism on said head for supporting and forming a first critical point for said at least one string,

a second mechanism on said body for supporting and forming a second critical point for said at least one string,

said first end secured to said head and said second end secured to said body, and

a tuning adjustment device comprising:

a first portion to tension said at least one string to playing pitch from an untensioned condition to at least one pitch tuning quickly, and

a second portion to further tension said at least one string at playing pitch,

wherein said second portion is in close proximity to said first portion,

wherein said tuning adjustment device is located on said body, and said tuning adjustment device further comprising:

at least one anchor connected with said second end, and

at least one third portion for pivoting said at least one anchor about an axis that is transverse to the axis of said at least one string in a first direction to tension said at least one string to said at least one pitch tuning.

2. A stringed musical instrument comprising:

a body,

a neck extending outwardly from said body,

a head located opposite said body on said neck,

at least one string extending from said body to said head, said at least one string having a first end and a second end,

a first mechanism on said head for supporting and forming a first critical point for said at least one string,

a second mechanism on said body for supporting and forming a second critical point for said at least one string,

said first end secured to said head and said second end secured to said body, and

a tuning adjustment device comprising:

a first portion to tension said at least one string to playing pitch from an untensioned condition to at least one pitch tuning quickly, and

a second portion to further tension said at least one string at playing pitch,

wherein said second portion is in close proximity to said first portion,

wherein said tuning adjustment device is located on said head, and said tuning adjustment device further comprises:

at least one anchor connected with said first end, and

at least one third portion for pivoting said at least one anchor about an axis that is transverse to the axis of said at least one string in a first direction to tension said at least one string to said at least one pitch tuning.

3. Apparatus of claim **2** wherein said tuning adjustment device further comprises at least one lock to impede pivoting said at least one third portion in a second direction.

4. Apparatus of claim **3** wherein said at least one lock allows pivoting of said at least one third portion in said first direction while impeding pivoting of said at least one third portion in said second direction.

5. Apparatus of claim **3** wherein said at least one lock further comprises a plurality of spaced-apart stops to impede pivoting said at least one third portion in said second direction.

6. Apparatus of claim **3** wherein said at least one lock further comprises at least one tooth formed on said at least one third portion that cooperates with at least one tooth to impede pivoting said at least one third portion in said second direction.

7. Apparatus of claim **2** wherein said second portion further comprises at least one tuner to vary the tension of said at least one string while said at least one third portion is in a locked position.

8. Apparatus of claim **7** wherein said at least one tuner further comprises a thumbscrew.

9. Apparatus of claim **7** wherein said at least one tuner further comprises a continuously variable element to continuously vary the tension in said at least one string.

10. Apparatus of claim **7** wherein said at least one tuner adjusts the position of said anchor.

11. Apparatus of claim **2** further comprising:

a nut, and

a bridge,

wherein said nut comprises said first critical point and said bridge comprises said second critical point,

wherein said a least one anchor is adjacent said nut opposite said second critical point.

12. Apparatus of claim **2** further comprising:

a nut, and

a bridge,

wherein said nut further comprises said first critical point and said bridge further comprises said second critical point,

wherein said a least one anchor further comprises said nut opposite said second critical point.

13. Apparatus of claim **2** wherein said at least one third portion further comprises an L-shaped elongated member.

14. Apparatus of claim **1** further comprising:

a nut, and

at least one bridge,

wherein said nut further comprises said first critical point and said at least one bridge further comprises said second critical point for said at least one string,

wherein said at least one anchor is adjacent said at least one bridge opposite said first critical point and move-

able therewith about said axis that is transverse to said axis of said at least one string.

15. Apparatus of claim 1 further comprises:

a nut, and

at least one bridge,

said nut further comprises said first critical point and said at least one bridge further comprises said second critical point for said at least one string, said bridge having a surface extending generally in the direction of said axis of said at least one string, wherein said at least one anchor further comprises said at least one bridge opposite said first critical point.

16. Apparatus of claim 15 wherein said second critical point has at least one location on said at least one bridge, said at least one bridge having a curved surface, said at least one bridge being pivotably displaceable about said axis that is transverse to the axis of said at least one string, said second critical point travels a critical distance on said curved surface of said at least one bridge changing said at least one location of said second critical point establishing harmonic tuning at said playing pitch as said at least one bridge is pivoted by tensioning said at least one string to said at least one pitch tuning.

17. Apparatus of claim 16 wherein said tuning adjustment device further comprises at least one lock to impede pivoting said at least one third portion in a second direction.

18. Apparatus of claim 17 wherein said at least one lock allows pivoting of said at least one third portion in said first direction while impeding pivoting of said at least one third portion in said second direction.

19. Apparatus of claim 11 wherein said at least one third portion further comprises an elongated lever.

20. Apparatus of claim 18 wherein said tuning adjustment device further comprises a tremolo.

21. Apparatus of claim 16 wherein said tuning adjustment device further comprises a fulcrum tremolo.

22. Apparatus of claim 1 wherein said tuning adjustment device further comprises a macro-tuner.

23. A stringed musical instrument comprising:

a body,

a neck extending outwardly from said body,

a head located opposite said body on said neck,

at least one string extending from saidbody to said head,

said at least one string having a first end and a second end,

a first mechanism on said head to support and form a first critical point for said at least one string,



a second mechanism on said body to support and form a second critical point for said at least one string,

said first end secured to said head and said second end secured to said body,

at least one string anchor located opposite said body on said head, and

a tuning adjustment device combining

a first portion to quickly tension said at least one string to playing pitch from an untensioned condition at said at least one of several pitch tunings,

a second portion to fine tune said at least one string at said playing pitch, and

at least one gripping portion intermediate said nut and said at least one string anchor for gripping said at least one string,

wherein said first portion, said second portion, and said at least one gripping portion and are in close proximity to each other.

24. A stringed musical instrument comprising:

a body,

a neck extending outwardly from said body,

a fulcrum tremolo,

a head located opposite said body on said neck,

at least one string extending from said body to said head, said at least one string having a first end and a second end, a first mechanism on said head to support and form a first critical point for said at least one string,

a second mechanism on said fulcrum tremolo to support and form a second critical point for said at least one string,

said first end secured to said head and said second end secured to said fulcrum tremolo,

said fulcrum tremolo further comprising:

a bearing portion to adjustably mount said fulcrum tremolo on said body for pivotal displacement, said bearing portion further comprising at least one bearing assembly, said bearing assembly further comprising at least a portion of a ball bearing surface.

25. Apparatus of claim 24 wherein said bearing assembly further comprises at least one shaft connected to said fulcrum tremolo.

* * * * *

# EXHIBIT E

US007470841B1

(12) **United States Patent**
**McCabe**

(10) **Patent No.:** **US 7,470,841 B1**
(45) **Date of Patent:** **Dec. 30, 2008**

(54) **TUNING APPARATUS FOR STRINGED INSTRUMENT**

(76) Inventor: **Geoffrey L McCabe**, 19995 Sischo Dr., Topoganga, CA (US) 90290

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(86) PCT No.: **PCT/US98/20376**

§ 371 (c)(1),
(2), (4) Date: **Oct. 23, 2001**

(87) PCT Pub. No.: **WO00/19405**

PCT Pub. Date: **Apr. 6, 2000**

(51) **Int. Cl.**
*G10D 13/02* (2006.01)

(52) **U.S. Cl.** .................................................. **84/312 R**

(58) **Field of Classification Search** ............... 84/312 R, 84/313, 314, 314 R, 314 N, 298–302, 307
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,261,240 A * 4/1981 Aaroe ......................... 84/726
4,506,585 A * 3/1985 Desmond ..................... 84/298
4,655,116 A * 4/1987 Matsui ..................... 84/297 R
4,742,750 A * 5/1988 Storey ......................... 84/267
4,763,555 A * 8/1988 Minakuchi et al. ............ 84/313
4,768,415 A * 9/1988 Gressett et al. ............... 84/298
5,381,716 A * 1/1995 May et al. ....................... 384/4
5,438,902 A * 8/1995 Baker ....................... 84/312 R
5,965,831 A * 10/1999 McCabe ...................... 84/313
5,986,190 A * 11/1999 Wolff et al. ............... 84/297 R
5,986,191 A * 11/1999 McCabe ...................... 84/313
6,563,034 B2 * 5/2003 McCabe .................. 84/312 R

* cited by examiner

*Primary Examiner*—Kimberly R Lockett

(57) **ABSTRACT**

A stringed musical instrument is provided with a tremolo with a unitary base plate formed from a single folded or bent plate including a spring attachment means portion so that the tremolo is connected directly to the biasing springs; such a folded construction also includes multiple tiers stamped into the base plate portion for displacing the height of the second critical point on the intonation modules relative to the body of the instrument; the spring attachment means portion is fashioned such that the openings for anchoring the ends of the strings are aligned to openings in the base plate for threading the strings through the intonation modules. Additionally, intonation modules include alternative means for anchoring the strings located a critical distance from the second critical point essentially equal to the length of the anchoring portion or the reinforcement windings of the strings but not sufficient in length to engage the second critical point so as to render that portion of the string between the second critical point and the string anchor substantially inextensible.

**31 Claims, 5 Drawing Sheets**

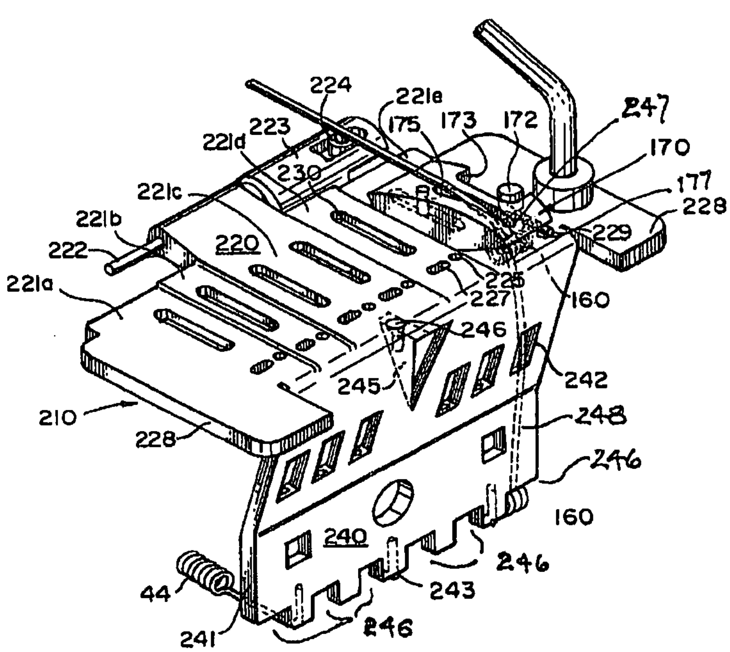

FIG. 1

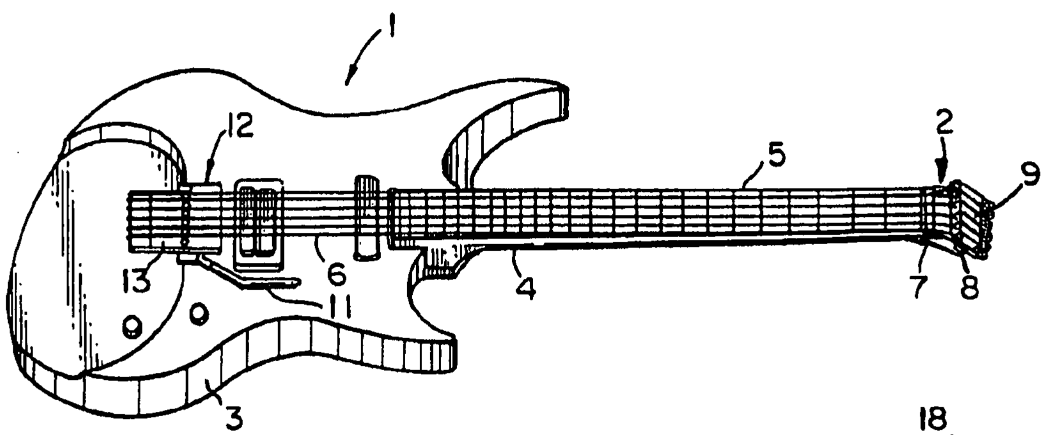
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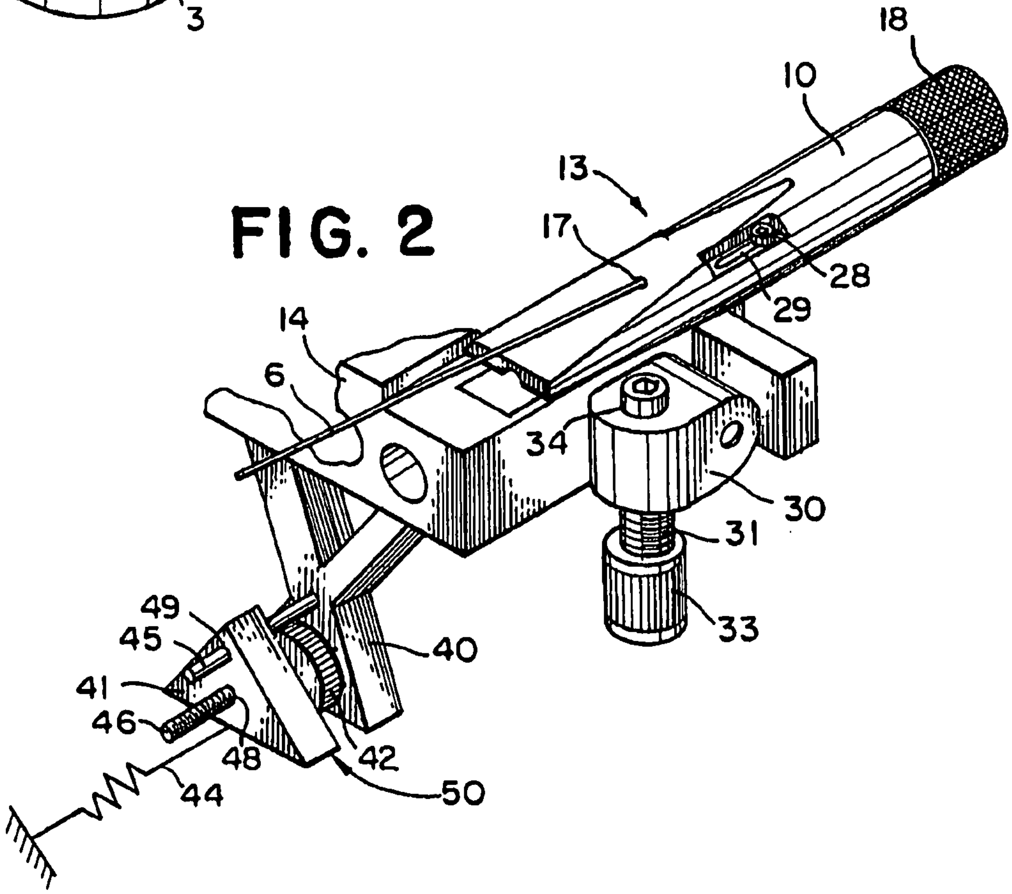
FIG. 2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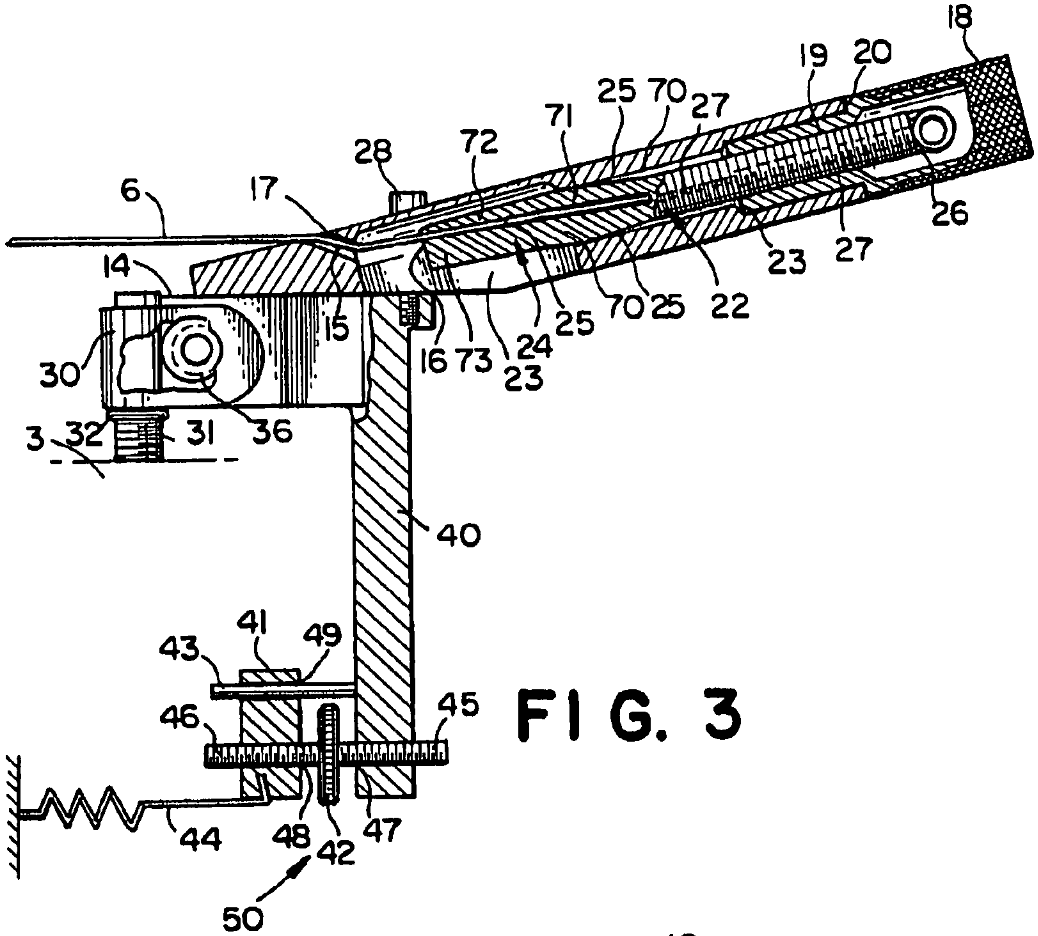
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FIG. 3

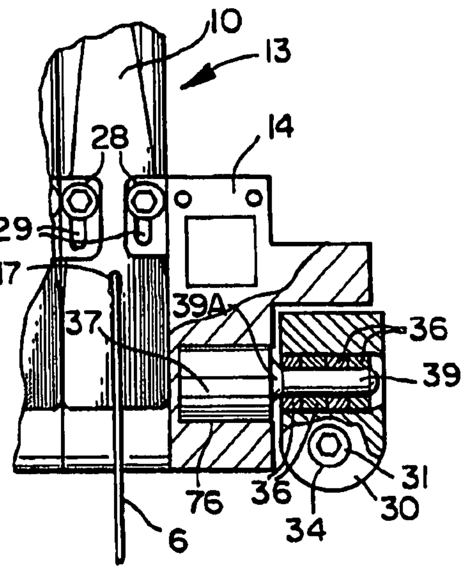
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FIG. 4

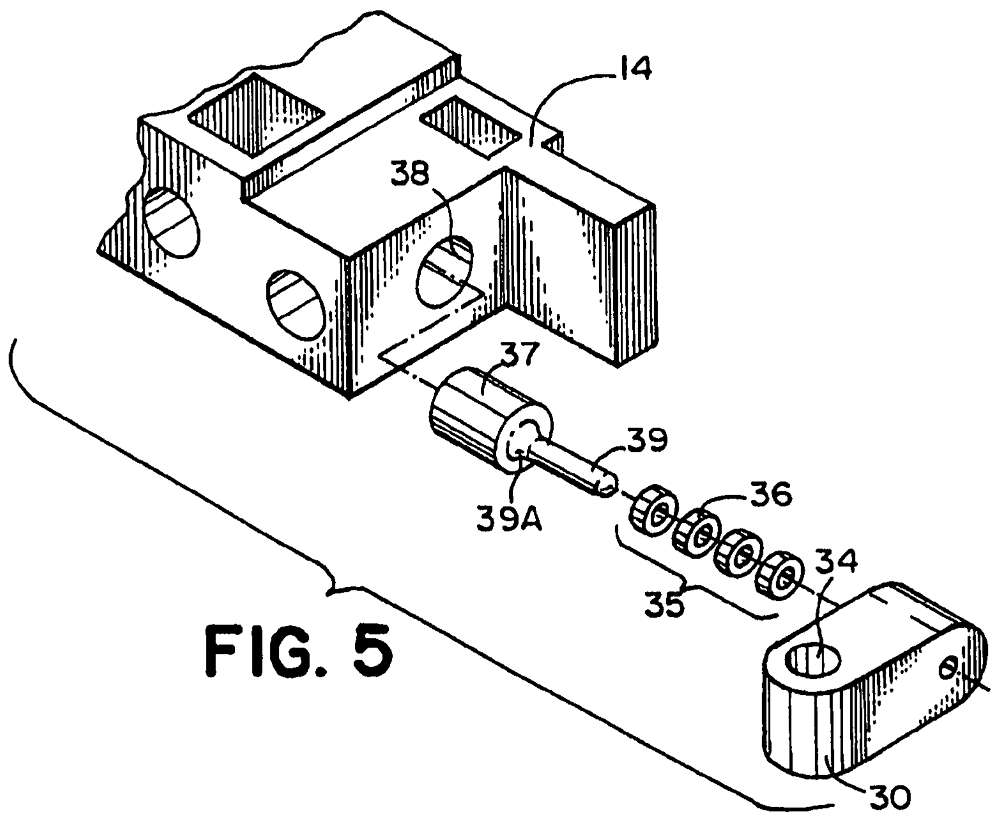


FIG. 5

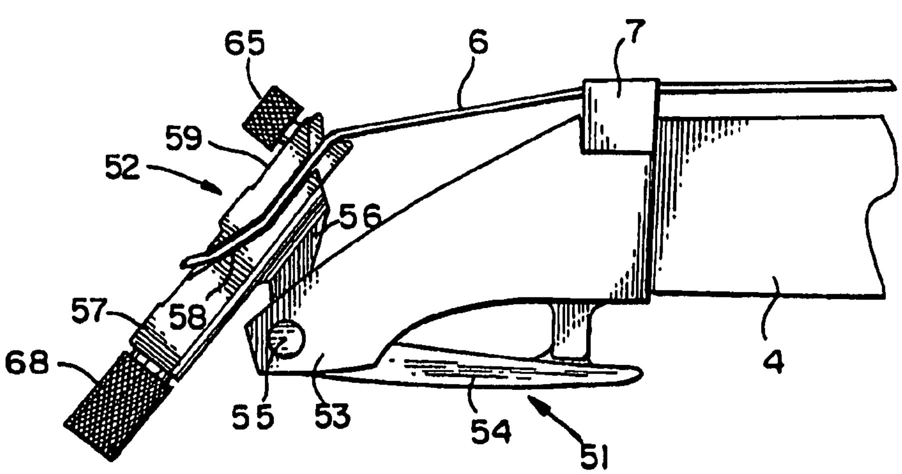


FIG. 6

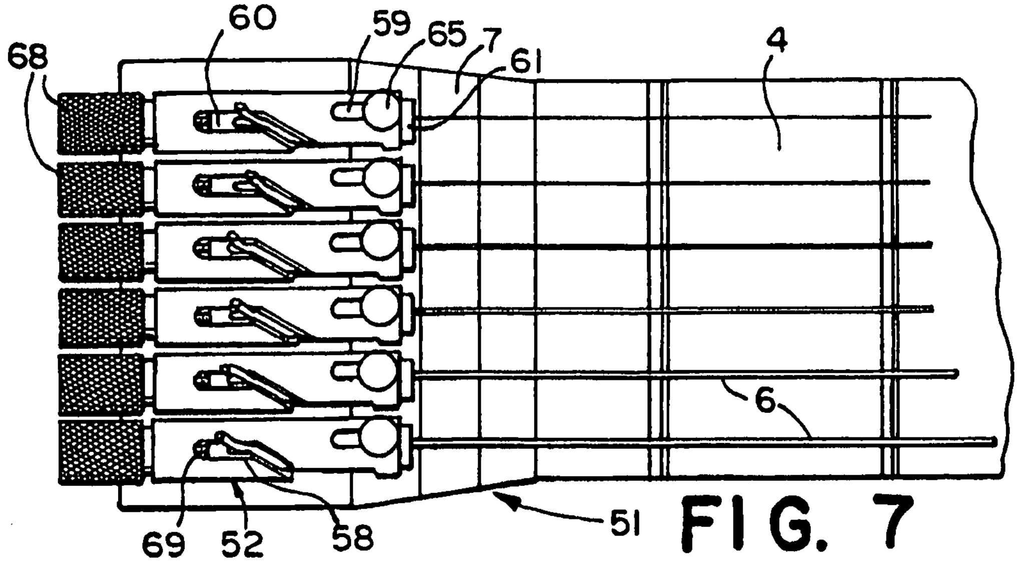


FIG. 7

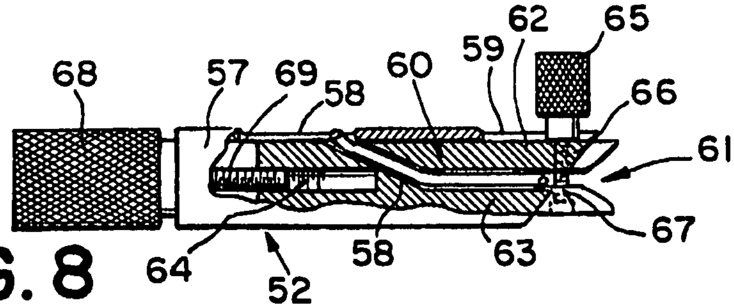


FIG. 8

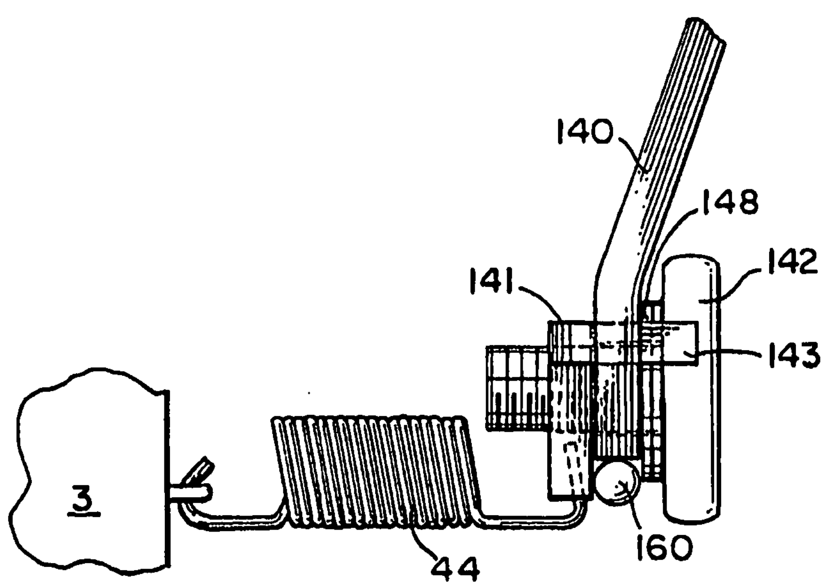


FIG. 9

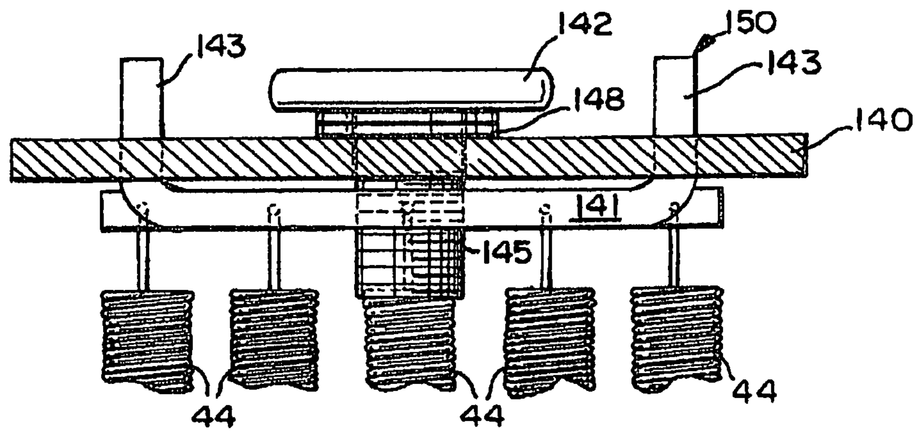
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FIG. 10

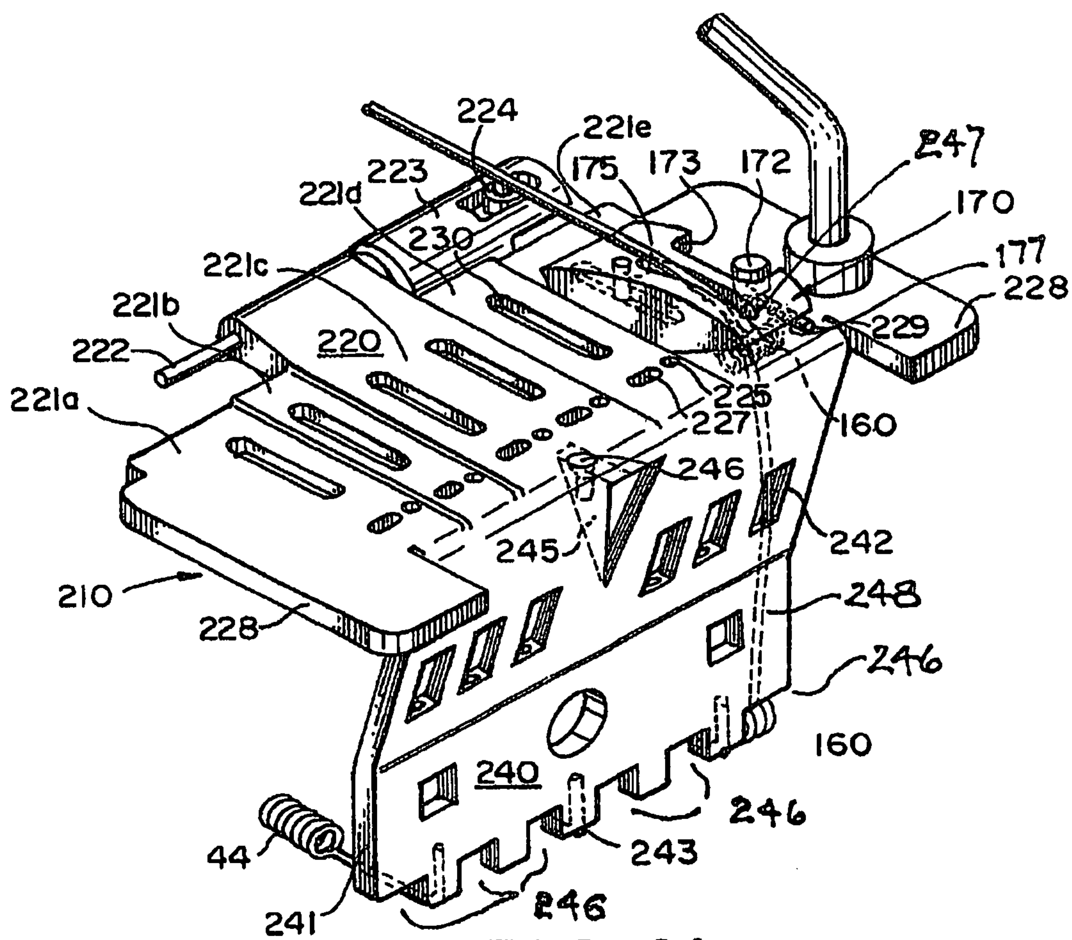
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FIG. 11

# TUNING APPARATUS FOR STRINGED INSTRUMENT

## BACKGROUND OF THE INVENTION

In a stringed musical instrument, such as a guitar, the strings extend unsupported between a first critical point usually formed by the nut where the neck joins the head and a second critical point usually formed by the bridge positioned on the body. The strings are anchored at one end on a portion of the instrument known as the tailpiece, strung over the bridge and the nut on the head of the instrument and in conventional instruments anchored on the other end to the tuning pegs where an untensioned string is tensioned and adjusted to a tuned condition. The second critical point is formed by a part of the bridge or by a part of a combined bridge and tailpiece structure. Traditionally, the size of the bridge elements are quite small so as to create a clearly defined single point of contact between the string and the bridge element. It is between these two points that the string length is determined. This is sometimes referred to as the scale length. Adjusting the relative distance between the first and second critical points is called harmonic tuning. Some bridge structures have individually adjustable bridge elements for each string. Often the typical construction of the strings, particularly for guitar and bass, have a plain end and a "ball end" in which a washer-like addition is wrapped by the string itself as a means to help in securing the string to the instrument on the tailpiece. The wrapping is typically thicker than the rest of the string so that the wrapping is substantially inextensible. The wrapping usually extends for at least a ½" towards the plain end and as such the tailpiece structure must insure that the wrapping does not extend over the second critical point when arranged on the instrument. Fine tuning has been a long standing problem for stringed musical instruments. In the Proelsdorfer U.S. Pat. No. 2,304,597, string tensioning devices placed on the tailpiece for fine tuning the pitch of the strings of violins, guitars and the like, were disclosed, however such pitch adjustment is quite limited in range and designed to offer the tuning of the strings a minor adjustment of pitch after the general tuning is achieved with the tuning pegs on the head of the instrument which first provides the means for raising and adjusting the tension of the strings to pitch from an untensioned condition.

It is known to those skilled in stringed musical instrument design and construction that various tremolos have been proposed and utilized for varying the tension of all the strings simultaneously for the purpose of creating a tremolo sound. Further, it is known to those skilled in the art that there are a great many commonly used names for such devices, such as tremolo, tremolo device, tremolo tailpiece, tremolo bridge, fulcrum tremolo, fulcrum tremolo bridge, fulcrum tremolo tailpiece, fulcrum tremolo bridge-tailpiece, vibrato, vibrato bridge, vibrato tailpiece, vibrato bridge tailpiece, etc.

In one specific species, known as the fulcrum tremolo, Fender U.S. Pat. No. 2,741,146, shows and provides a tremolo device which incorporates a novel bridge structure which incorporates the tailpiece and is commonly known to specifically provide the anchoring means for the strings. The bridge plate is also known as the base plate. The base plate upon which the individual bridge elements are adjustably secured has a beveled ridge portion which is secured to the instrument body by six screws for permitting pivotal movement about a fulcrum axis which varies the tension on the strings and produces the desired tremolo effect. The tailpiece is integrated into a spring block descending from the base plate into a cavity within the instrument body. Further, the



bridge and the tailpiece both move together as the tremolo device is pivoted. The ball ends and wrapping of the strings are anchored into the recesses in the end of the string block furthermost from the base plate. The strings being threaded through bores individual to each string over two inches in length within the spring block continuing out through the bottom of the base plate and over the bridge elements towards the nut. A singular aspect of the fulcrum tremolo is that the harmonic tuning is upset as the device is pivoted.

Typically, when a fulcrum tremolo pivots about its fulcrum axis, counter springs are utilized to counteract to pull of the strings. Counter springs are usually connected to the body of the instrument at one end and to an attachment means on the bottom of the tremolo at the other end. One of the most troublesome problems with prior art has been maintaining the initial tuning at proper playing pitch. When a musician plays on the sting there is usually some kind of string stretch over time that results in the overall tuning going out of balance. Similarly, the use of the tremolo itself may also introduce string stretch. Further, various factors such as the changes in the humidity of the atmosphere causing the wood in the neck and/or body of the instrument to swell often create subtle distortions in the instrument's geometry which would then in turn disturb the equilibrium point between the tension of the strings and the tension of the counter springs and then as a consequence disturb the initial position. Initial position refers to a specific equilibrium point between the tension of the strings and the tension of the counter springs at the intended tuned pitched condition of the strings. Often the pivot means is subject to wear and the tremolo does not always return to its initial position. For the distance from the bridge elements to the anchoring points, there is an additional amount of unplayable string that is further subject to stretch. Where such demands on the tremolo are minimal this disadvantage is often traded-off for the advantage this extra length contributes as a "looser" feel in playing the instrument.

Improvements to the Fender U.S. Pat. No. 2,741,146 fulcrum tremolo have included using string clamps at the nut and immediately behind the intonation points on each of the bridge elements to limit string stretch to within these two points that define the scale length and separately adopting a novel beveled edge adjustably supported by two screw-like members positioned in the body at the fulcrum point to improve the return to initial position after pivoting the tremolo device (Rose U.S. Pat. No. 4,171,661). In Rose U.S. Pat. No. 4,497,236 a combination of the bridge elements, the tailpiece and fine tuners replaced the "novel bridge structure" incorporating the tailpiece of the Fender device and Rose U.S. Pat. No. 4,171,661 so that within the limited range (typically less than a whole tone) the strings could be re-tuned without unlocking the string clamps at the nut. However, string stretch beyond the range of the fine tuners necessitated a correction that is tedious and time consuming involving unlocking the string clamps, re-tuning the strings, re-adjusting the clamp, and re-tuning all the other strings to re-balance the equilibrium point back to initial position.

Therefore, for stringed musical instruments, as is known to those skilled in the art:

- the second critical point is a clearly defined point on the bridge or individual bridge elements, the adjustment of which relative to the first critical point on the nut defines the length of the string or scale length and is called harmonic tuning; for fulcrum tremolos as originated by Fender U.S. Pat. No. 2,741,146, when pivoted:
- both the bridge portions and the string anchoring means, the tailpiece, simultaneously move about a fulcrum axis;
- there is a tendency for the harmonic tuning to be upset; and

various factors can disturb the equilibrium point between the tension of the strings and the tension of the counter springs and as a consequence disturb the initial position; and for those fulcrum tremolos equipped with fine tuners as with Rose U.S. Pat. No. 4,497,236, Storey U.S. Pat. No. 4,472,750 and Fender U.S. Pat. No. 4,724,737:

the fine tuners simultaneously move with the bridge and tailpiece portions about the fulcrum axis when the device is pivoted; and

fine tuners are designed to offer the tuning of the strings a minor adjustment of pitch after the general tuning is first achieved by the tuning pegs on the head of the instrument; and for those fulcrum tremolos fitted with string locks at the first and second critical points as in Rose U.S. Pat. No. 4,171,661,

string stretch beyond the clamps at the first and second critical points is eliminated offering the most stability of tuning possible for the set of problems associated with string stretch.

In Steinberger U.S. Pat. No. Re. 31,722 stringed musical instruments without tuning pegs placed in the typical fashion on the head of the instrument were commonly known as "headless" stringed musical instruments. The replacement tuning machines were mounted on the body opposite the side where the neck joins the body.

In Takabayashi U.S. Pat. No. 4,608,905 describes an improvement on fulcrum tremolos incorporating "octave tuners", tuners which functioned as the tuning pegs at the head of the instrument and as such integrated the tailpiece function in the tuning means. The bridge portion of the device comprised a "roller" configuration for the second critical point similar to Storey U.S. Pat. No. 4,742,750 and Steinberger U.S. Pat. No. 4,704,936. A cylindrical portion distanced from the bridge portion adjustably secured to the base plate houses a string holder member for one end of the string which is "fitted in such a manner as to be allowed to move freely in the axial direction". The ball end of each string is arranged to be anchored "to the rear end opening of the string holding members" which is adjustably positionable "in the stretching direction of the strings for effecting octave tuning". The string continues through the string holder member sufficient in size to ensure that the wrapping of the ball end does not extend over the second critical point and then passes on over the bridge element towards the nut. In this device the string holder member accomplishes the tailpiece function by anchoring the string at a single point which moves accordingly when the string holder member is displaced to achieve the tuning of the instrument.

Further improvements in the fulcrum tremolo utilized an arrangement with ball bearings at the pivot point within a housing adjustably mounted to the body which not only improved return to initial position after use of the tremolo but also virtually eliminated the wear and tear associated with prior art (McCabe U.S. patent application Ser. No. 07/607,458, Continuation No. 08/027,729, filed Jan. 14, 1993).

Additionally, the replacement of fine tuners with macro-tuners on a fulcrum tremolo (McCabe U.S. patent application Ser. No. 07/607,458, Continuation No. 08/027,729, filed Jan. 14, 1993) provided an intonation module that included a novel integrated one piece bridge-tailpiece structure secured to the base plate where each string anchored within its respective structure passes through a separate lever member and over the bridge element wherein the lever member could be displaced by an adjustment bolt to provide the means to bring and adjust the strings to playing pitch from an untensioned condition circumventing the re-tuning limits imposed by the fine tuner arrangements. These macro-tuners are often part of an intonation module dedicated to each string for use with but not exclusive to "headless" stringed musical instruments, that is, instruments without tuning pegs placed in the typical fashion on the head of the instrument. Certainly, a fulcrum tremolo with macro-tuners could be used with instruments which had tuning pegs without a disadvantage. Further, macro-tuners could be placed on the head or the body of the instrument and if integrated with a string anchoring means could replace the tuning pegs.



Macro-tuners refer to tuners with the capacity to raise and adjust the tension of the strings from an untensioned condition to a proper playing pitch, an as such provide for alternate tunings and compensation for substantial string stretch during the life of the string essentially without additional means.

Often the musician is called upon to play in an ensemble where the other instruments are not tuned to a typical concert pitch. Accordingly, the musician must flatten or sharpen the initial tuning of all the strings on his instrument in order to meet the pitch requirements of other instruments. This re-tuning often disturbs the initial position because the tension of the counter springs has not been readjusted as well. Accordingly, the position of the base plate of the tremolo is either tilting away from or towards the body of the instrument which then can limit the range in which the tremolo can be activated. Steinberger U.S. Pat. No. 4,632,005 and Gunn U.S. Pat. No. 4,955,275 provide for an adjustable counter spring and utilize an adjustment knob that provides a means to vary tension of the counter spring and thereby maintain the equilibrium point between the tension of the counter spring and the tension of the strings on fulcrum tailpiece tremolo, that is, a tremolo device where the bridge elements do not pivot with the anchoring means and, therefore, do not upset the harmonic tuning as such.

The "octave tuners" of the Takabayashi fulcrum tremolo U.S. Pat. No. 4,608,905 anchor the strings at a point on the string holder member spaced on the opposite side from the second critical point on the bridge elements. This arrangement presents serious problems for this tremolo device:

the length of the string subject to stretch beyond scale length, which includes the additional string length as measured from the bridge element to the anchoring point, is increased excessively in general at initial position and far more so when the device is pivoted in view of Rose U.S. Pat. No. 4,171,661 and,

tensioning of the strings which holds the ball end of the string securely against the rear end opening of the string holding member is inadequate to keep the ball ends as originally seated in initial position throughout the performance range of the tremolo; such mis-seatings are devastating to the effort to maintaining a tuned instrument.

## SUMMARY OF THE INVENTION

Accordingly, an object of this invention is to provide improvements in the mounting means of the bearing and bearing housing arrangement for pivotally supporting the base plate of the fulcrum tremolo that will allow a greater range of installation possibilities.

It is a further object of the invention to provide the intonation modules with macro-tuners integrated with a string anchoring means, known to those skilled in the art as a tailpiece and a separate string holder element that functions to additionally secure the string adjustably to the fulcrum tremolo at an additional point and an adjustment bolt threadedly engaged with the string holder element for slideably positioning the string holder element relative to the second

critical point for macro-tuning. The string holder element includes a gripping means in the form of a fork-like element or collet. The string gripping means is disposed within the intonation module structure that grips and secures the string as close as possible to the second critical point I order to limit the length of the string that would otherwise be subject to stretch and provides for an anchoring means that remains stable through the performance range of the tremolo. By threading the adjustment bolt, the string tensioning element is slideably displaced:

increasing the tension of the associated string to a proper pitched condition and varying the tension of the string thereof so as to provide the macro-tuning function, and

drawing the fork-like string clamping means of the string tensioning element within the restricted portion of a sleeve-like portion of the intonation module structure, compressing and closing the forks upon the string at the clamping point for transferring the anchoring of the string to an improved anchoring means positioned at the end of the string tensioning element closest to the second critical point.

Yet, another object of the invention is to provide a global tuning mechanism on the fulcrum tremolo that compensates for the problems associated with varying humidity on the instrument as well as other factors that could affect the instrument's geometry. Further, a global tuner would also provide a simple and quick means for the musician to adjust the initial position in order to meet the pitch requirements in varied situations. Further, the global tuner in re-establishing the initial position allows the full range of pivoting the tremolo. Global tuners refer to a means on a fulcrum tremolo with the capacity to adjust the equilibrium point between tension of the counter spring(s) and the tension of the strings in order to compensate for changes in tension requirements on the strings and/or the counter springs. The global tuner preferably employs an adjustment knob for providing continuously variable adjustment of the tension in the strings by varying the relative distance between the spring attachment means on the base plate of the tremolo and the attachment point of the springs to the body.

Another object of the invention is to replace the fine tuner portion on each of the L-shaped arms of the "semi-headless" tuners with macro-tuner mechanisms and, therefore, provide for greater range and easier use. This advancement for adjustably securing each string to a improved clamping means positioned within a sleeve-like portion on one end of a L-shaped arm provides the capacity to tune the string from an tensioned condition to pitched string condition. Each L-shaped arm can pivot and be selectively positioned to a number of pre-set positions relative to the nut or first critical point for raising from an untensioned to a pre-set pitched string condition.

Yet another object of the invention is to provide a fulcrum tremolo having an alternate string anchoring points **247** that are spaced apart from one another. One anchoring point **246** is provided at the bottom of the spring block or spring blade so that the anchoring point **246** is remote from the second critical point. The alternate anchoring point **247** is located adjacent the second critical point so that the length of the string between the second critical point and the string anchor **160** is substantially shorter when the string is anchored at the alternate anchoring point **247**. Specifically, the alternate anchoring point **247** is located a distance from the second critical point that is substantially equal to the length of the wrappings on the end of the strings **160**.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had by the accompanying drawings and descriptive matter in which there are illustrations and described preferred embodiments of the invention.



## DESCRIPTION OF THE DRAWINGS

The foregoing summary as well as the following detailed description of the preferred embodiment of the present invention will be better understood when read in conjunction with the appended drawings, in which:

FIG. **1** is a plan view of an electric guitar embodying the present invention.

FIG. **2** is a perspective view of the macro-tuners, bearing mounting arrangement and global tuner of the present invention as used in the electric guitar.

FIG. **3** is a side view cross-section of the tremolo mechanism showing the macro tuners, bearing mounting arrangement and the global tuner.

FIG. **4** is a top view cross-section of the ball bearings, the housing mounting means.

FIG. **5** is an exploded perspective view of the bearing ball bearings, the housing mounting means.

FIG. **6** is a side view of the "semi-headless tuners" with two macro-tuning means.

FIG. **7** is a top view of the "semi-headless tuners" attached to the neck of the guitar.

FIG. **8** is a cross-section view of the side of a macro-tuning mechanism.

FIG. **9** is an enlarged fragmentary side view of an alternate embodiment of a global tuning mechanism.

FIG. **10** is a plan view partially in section of the global tuning mechanism illustrated in FIG. **9**.

FIG. **11** is a perspective view of an alternate embodiment of a fulcrum tremolo according to the present invention, base plate for a fulcrum tremolo

## DETAILED DESCRIPTION OF THE INVENTION

In FIG. **1**, an electric guitar **1** is illustrated comprising a head **2** at one end, a body **3** at the other end, which a neck **4** extending between the head and the body. Six strings **6** extend from head **2** to body **3** over neck **4**. Neck **4** forms fret board **5** for guitar **1**. At head **2**, each of the strings extends over nut **7** forming the first critical point for the strings. Nut **7** is located at the transition of neck **4** to head **2**. Each string **6** is secured on the head by anchor **8** and each anchor has a corresponding tuner **9**. On the body **3**, strings **6** are secured to fulcrum tremolo **12**. Fulcrum tremolo **12** has arm **11** for pivoting the tremolo and providing the vibrato effect on the strings. Fulcrum tremolo **12** has six intonation modules **13**. The intonation modules present improvements to the macro-tuning invention which incorporates the function of the bridge element and tail-piece in its structure as well as the capacity to adjustably secure the individual strings to the instrument. The intonation modules are movable and thereby provide a means to change the distance between the first and second critical points or the harmonic tuning as such.

The invention is shown for us on electric guitar **1** and it should be understood that the invention could be used on a variety of stringed musical instruments. In body **3** of guitar **1** there are electric pickups. Fulcrum tremolo **12** forms a second critical point for strings **6**, sometimes characterized as an intonation point or bridge point.

In the following description, fulcrum tremolo **12** will be described in greater detail. In FIG. **2**, fulcrum tremolo **12** is shown on an enlarged scale compared to FIG. **1**. FIG. **3** displays fulcrum tremolo **12** of FIG. **2** in a cross-section view. The second critical point is located near the front intonation modules **13**. Outwardly from intonation modules **13** on each side of the opposite sides of base plate **14** extending in the direction of the strings there are bearing housings **30**. The bearing housing **30** supports base plate **14** pivotally relative to body **3**. Global tuner **50** is positioned between spring block **40** extending downwardly form the bottom of base plate **14** and counter springs **44** connected to instrument body **3**.

In FIGS. **2** and **3**, one of the intonation modules **13** is shown including a shaped barrel-like base **10** with a second critical point formed at string opening **17**. Base **10** is adjustably secured to base plate **14** of fulcrum tremolo **12** by machine screws **28** through slots **29**. Loosing machine screws **28** permits longitudinal movement of base **10** and associated parts for harmonic tuning of string **6**. Adjustment bolt **18** first passes through opening **20** in base **10** and threaded portion **19** of adjustment bolt **18** is engaged with threaded portion **21** of string tensioning element **22** within sleeve-like portion **23** of base **10**. String **6** of the musical instrument makes critical contact with base **10** at the string opening **17** to passageway **15** sloping downwardly and rearwardly through base **10** until the string passes into a sleeve-like portion **23**. String **6** continues passing through clamping point **16** of string tensioning element **22**, through slots **25** between upper fork **72** and lower fork **73** of fork-like string clamping means **24**, through string passageway **27** of string tensioning element **22** and is secured at exit **26**. Annular flange-like portion **71** of fork-like string clamping means **24** of string tensioning element **22** is in bearing contact with restricted portion **70** of sleeve-like portion **23** of base **10**. Threading adjustment bolt **18** slideably displaces the string tensioning element **22** relative to string opening **17** providing an adjustment whereby tension or pull on string **6** is applied and varied for raising and adjusting the strings **6** from an untensioned condition to a pitched string condition: additionally, annular flange-like portion **71** of fork-like string clamping means **24** of string tensioning element **22** is drawn within restricted portion **70** of sleeve-like portion **23**, clamping string **6** between upper fork **72** and lower fork **73** at clamping point **16** adjacent to string opening **17**.

In FIGS. **2**, **3**, **4** and **5** outwardly from intonation modules **13** on each side of the opposite sides of base plate **14** shown at the forward end of fulcrum tremolo **12** extending in the direction of the strings, there is bearing housing **30**. Bearing housing **30** is adjacent to base plate **14**. Housing **30** is adjustably supported relative to body **3** of the instrument by threaded post **31** with annular flange **32**. Post **31** is threaded into insert **33** in body **3**. By threading post **31** into insert **33**, the spacing between body **3** and housing **30** is selectively adjustable. Adjustment of post **31** is effected through an oval opening **34** in the top of housing **30**. In housing **30** rearward post **31**, there is opening **76** extending transversely of the string direction of guitar **1** containing bearing assembly **35**, formed by four side-by-side roller bearings **36**. Insert **37** fits into cut-out **38** in the side of base plate **14** with pin **39** with annular flange ***39a*** extending outwardly through bearings **36**. Annular flange ***39a*** on pin **39** spaces the side-by-side roller bearings **36** from base plate **14**. Accordingly, by manipulating tremolo arm **11**, fulcrum tremolo **12** can be pivoted about pin **39** to achieve the desired tremolo effect.

As can be seen in FIGS. **2** and **3** there is spring attachment means **40** extending downwardly from base plate **14**. The preferred embodiment incorporates thumb screws **42** with shaft **45** threadedly engaged with threaded opening **47** in spring block **40** on one side of thumb screw **42** and another shaft **46** with reverse threads in the opposite direction of shaft **45** threadedly engaged with reverse threaded opening **48** in spring holder **41**. Counter springs **44** are attached at one end to spring holder **41** and to body **3** on the other end of counter springs **44**. Guide pin **43** extending outwardly from spring block **40** towards spring holder **41** passes through guide pin opening **49** in spring holder **41** limiting longitudinal rotational movement of spring holder **41** relative to spring block **40**. By threading thumb screw **42** clockwise relative to spring holder means **41**, spring holder **41** moves closer to spring block **40** increasing the tension of the counter springs **44** and by threading thumb screw **42** counter-clockwise relative to spring holder means **41**, spring holder **41** moves away from spring block **40** decreasing the tension of the counter springs **44** providing the means to adjust the equilibrium point and globally tune fulcrum tremolo **12**.

FIG. **6** displays an improved "semi-headless" tuner arrangement for stringed musical instruments. In FIG. **7**, the end of neck **4** is shown with strings **6** each of a different size. The strings **6** pass over nut **7** and each string is secured by string tensioning tuning device **51**, a "semi-headless tuner". There is a separate macro-tuning device **52** for each string.

The device, as set forth in FIGS. **6** & **7** includes bracket **53** secured to and projecting from the end of neck **4**. L-shaped lever **54** is pivotally connected by pin **55** as shown in FIG. **6**. The other or second arm **56** of lever **54** extends from pivot pin **44** toward the end of neck **4**.

At the end of second arm **56** there is sleeve-like portion **57**. String slot **58** extends longitudinally along sleeve-like portion **57** continuing disposed at an angle towards the top of the sleeve. Slot **59** at the free end of the sleeve extends towards the connected end of second arm **56**.

Adjacent the free end and within sleeve-like portion **57**, there is string clamping means **60** with fork-like portion **61** with upper fork **62** and lower fork **63** and at the opposite end there is threaded opening **64**. Thumb screw **65** passes through slot **59** in sleeve-like portion **57** and through unthreaded opening **66** in upper fork **62** and is threadedly engaged with threaded opening **67** in lower fork **63**. String **6** is arranged through slotted opening **58** and into slotted opening **75** between upper fork **62** and lower fork **63**. Threading thumb screw **65** clamps the upper fork **62** and lower fork **63** on string **6**, securing string **6** to string clamping means **60**.

Adjustment bolt **68** is adjustably mounted within sleeve-like portion **57** opposite the free end. Threaded portion **69** of adjustment bolt **68** is threadedly engaged with threaded opening **64** adjustably securing string clamping means **60** to macro-tuner **52**. By threading adjustment bolt **68** the clamping means can be displaced relative to nut **7** wherein the tension on string **6** can be raised and varied whereby the macro tuning can be achieved.

Referring to FIG. **8**, a single macro-tuning device is shown in which string **6** passes through slots **58** of sleeve-like portion **57** and is arranged between upper fork **62** and lower fork **63** of fork-like portion **61** of string clamping means **60** and clamped and secured by thumb screw **65** wherein threaded portion **69** of adjustment bolt **68** is threadedly engaged with threaded opening **64** of string clamping means **60**. By threading adjustment bolt **68** the position of string clamping means **60** relative to the anchoring means at the opposite end string **6** is increased and varied whereby tension or pull on string **6** is applied and varied for raising and adjusting the strings **6** from an untensioned condition to a pitched string condition.

Referring now to FIGS. **9-10**, an alternate embodiment of a global tuner **150** is illustrated. The global tuner **150** is shown

in connection with a fulcrum tremolo having an integral base plate and spring blade 140 similar to the fulcrum tremolo shown in FIG. 11 and described below. Alternatively, the global tuner may be incorporated into a fulcrum tremolo having a separate base plate and spring block or spring blade.

The global tuner 150 includes a spring blade 140 connected to the base 14 of the tremolo, and extending into a cavity in the body 3 of the musical instrument. A plurality of counter springs 44 bias the tremolo against the tension in the strings. The springs are connected at one end to the body 3 of the instrument. The second end of each spring is connected to a spring holder 141. The spring holder 141 has a plurality of sockets, each of which receives the second of one of the springs. An internally threaded aperture extends through the thickness of the spring holder, and is aligned with an aperture through the thickness of the spring blade 140. A thumbscrew 142 extends through the aligned apertures in the spring blade 140 and the spring holder 141, threadedly engaging the spring holder. Preferably a low friction element, such as a teflon washer 148 is disposed about the shaft 145 of the thumbscrew 142, between the head of the thumbscrew and the spring blade 140. Additionally, preferably, the spring holder 141 includes a pair of alignment tabs 143 integral with the body of the spring holder. The alignment tabs 143 mate with cooperating apertures in the lower end of the spring blade 140 to prevent vertical and lateral relative movement between the spring blade and the spring holder, while allowing longitudinal relative movement between the spring blade and the spring holder. Additionally, the lowermost edge of the spring blade 140 includes a plurality of notches or recesses for receiving the anchoring ball 160 at the end of the instrument strings if desired. If a plurality of macrotuners is utilized as described above, then the anchoring balls are engaged by the macrotuners. As in the previous embodiment, by turning the thumbscrew 165, the extension of the springs 144 is varied, which in turn varies the bias in the springs 144, thereby globally tuning all of the strings simultaneously.

Referring now to FIG. 11, an alternate fulcrum tremolo 210 having a base plate 220 that incorporates an integral spring blade 240 is illustrated. The base plate 220 is generally planar having a horizontal bore through the width of the base plate. A rod 222 extends through the horizontal bore and is supported at both ends by ring bearings 223 located within two bearing housing. For clarity, only one bearing housing is illustrated in FIG. 11. The rod 222 forms the fulcrum axis for the fulcrum arm, so that the fulcrum tremolo is pivotable about the rod 222. An adjustment screw 224 threadedly engages the bearing housing 223. The adjustment screw 224 vertically displaces the fulcrum axis and the base plate relative to the body of the musical instrument. The adjustment screw 224 is substantially aligned with the pivot axis so that the pivot axis intersects the vertical axis of the adjustment screw. Alternatively, as shown in FIGS. 3 and 4, the pivot axis may be rearwardly spaced from the adjustment screw.

The base plate 220 includes a plurality of sockets 225 for connecting intonation modules to the base plate. In the present instance, the sockets 225 are threaded so that a screw can be used to connect intonation modules to the base plate. The present base plate is configured to receive six intonation modules. However, the base plate can be configured to receive a different number of intonation modules for different application. For clarity, in FIG. 11 only, a single intonation module 170 is illustrated. The intonation module in FIG. 11 simply comprises a bridge element. Alternatively, the intonation module can incorporate a macrotuner as discussed above and illustrated in FIG. 8.

The intonation module 170 is connected to the base plate 220 by an attachment screw 172 that threadedly engages a threaded socket 225 in the base plate. An alignment pin 175 projects from the button of the intonation module 170 and engages a longitudinally elongated slot 230 in the base plate. The base plate includes similar slots and threaded sockets for attaching five similar intonation modules.

The intonation module 170 includes a longitudinally elongated slot 173 for receiving the attachment screw 172. The elongated slot 173 allows longitudinal adjustment of the intonation module 170, which adjusts the position of the bridge element that forms the second critical point for the corresponding string. Accordingly, the second critical point can be moved toward or away from the first critical point by loosening the attachment screw 172 and moving the intonation module. The ends of the slot 173 in the intonation module 170 form forward and rearward stops limiting the longitudinal movement of the intonation module. The sides of the slot 230 that receives the alignment pin 175 form side stops limiting lateral movement of the intonation module. In addition, preferably the base plate includes an adjustment screw 229 for adjusting the longitudinal position of the intonation module.

The base plate is operable with intonation modules that include a macrotuner as described above. Such intonation modules provide an anchor for anchoring the anchoring ball or string anchor 160 that is at the end of the string. Alternatively, an intonation module that provides two alternate string anchoring points can be utilized. Such an intonation module 170 is illustrated in FIG. 11.

The spring blade 240 provides anchoring points 246 for the string anchor. String anchor 160 is seated in one of the notches 246 at the bottom of spring blade 240. The string extends upwardly through an elongated cylindrical passageway 248 both illustrated in phantom in FIG. 11 in lower portion of 241 of the spring blade 240. The string then passes through an opening in the spring blade referred to as string passageway 242. From the string passageway 242 the string passes through string hole 227 in the base plate 220. The string then passes through the intonation module 170 and over the second critical point.

The intonation module 170 is configured so that the distance from the rearward outer surface 177 of the intonation module to the second critical point is approximately equal to the length of the wrapping of the string, the length of the wrapping being slightly less than the distance between the second critical point and the rearward surface of the intonation module. In this way, the wrapping of the string does not engage the second critical point. Further, the length of the string rearward of the second critical point is substantially inextensible.

Accordingly, the intonation module provides alternate anchoring points. Connecting the strings so that the string anchors 160 are anchored at the bottom of the spring blade 240 provides for an extended length of string rearward of the critical point that is subject to stretch so that the fulcrum tremolo creates a "looser" feel for the user. Alternatively, the strings can be anchored to the rearward end of the intonation module.

The base plate 220 may be substantially planar. However, in the present instance the base plate is multi-tiered, having five tiers for receiving the intonation modules. The first tier 221*a* receives the sixth intonation module. The next tier 221*b* is approximately 0.020 inch higher than the first tier 221*a*, and it receives the fifth intonation module. The third tier 221*c* is approximately 0.020 inch higher than the second tier 221*b*, and it is approximately twice as wide as the second tier, so that the third tier is sized to receive the third and fourth intonation

modules. The fourth tier **221***d* is approximately 0.020 inch lower than the third tier **221***c*, so that the fourth tier is substantially the same height as the second tier **221***b*. The fourth tier **221***d* receives the second intonation module. The fifth tier **221***e* is approximately 0.020 inch lower than the fourth tier **221***d*, so that the fifth tier is substantially the same height as the first tier **221***a*. The fifth tier receives the first intonation module, which is illustrated in FIG. **11**.

As noted above, the spring blade **240** is integrally formed with the base plate **220**. The spring blade **240** projects transverse vertically downwardly from the base plate **220**. A reinforcing rib **245** extends transverse the spring blade **240** and the base plate **220**, connected to the spring blade and the base plate. In the present instance the reinforcement rib **245** is integral with the spring blade **240**, and a fastener **246**, such as a screw, connects the reinforcement rib to the base plate **220**. The lower portion of the spring blade **241** forms an angle with the upper portion of the spring blade **240**. At least one spring socket **243** is formed into the lower portion of the spring blade **241**. The spring socket **243** is a generally cylindrical cavity for receiving the end of a spring that is connected to the body of the instrument. The spring biases the tremolo against the tension in the strings as discussed above. Alternatively, a global tuner similar in construction to the global tuner **50** described above can be utilized. Such a global tuner is disposed between the spring blade **240** and the spring to alter the bias that the spring applies to the spring blade.

The base plate **220** and spring blade **240** are integrally formed from a single piece of material as follows. A single piece of plate material, such as 7/64" plate steel is provided. The plate is stamped to form the multiple tiers **221***a-e*. The forward edge of the plate is folded over on itself to form a ridge across the central portion of the width of the plate that is at least twice the thickness of the plate material. A plurality of fasteners, such as screws rigidly connect the two layers of the ridge to one another. The bore of the fulcrum axis is then formed in the ridge, preferably by drilling the bore laterally through the width of the ridge.

Two parallel spaced-apart slots are formed in the plate. The slots extend forwardly from the rearward edge of the plate and terminate rearwardly from the forward edge of plate. The portion of the plate between the slots forms the spring blade **240**. The portion of the plate forward of the terminated slots forms the base plate **220**. The reinforcing rib **245** is cut from the portion of the plate that forms the spring blade **240**. One end of the reinforcing rib is left uncut, so that the reinforcement rib is integral with the spring blade **240**.

The spring blade is formed by bending the portion of the plate between the two terminated slots vertically downwardly, so that the spring blade is transverse the base plate **220**, projecting downwardly and forwardly toward the forward edge of the base plate. The width of the spring blade **240** is narrower than the width of the base plate **220** so that bending the plate to form the transverse spring blade forms two spaced-apart tabs **228** extending rearwardly from the base plate, integral with the base plate, and straddling the spring blade. The lower portion of the spring blade **241** is then bent transverse the upper portion of the spring blade, so that the lower portion **241** projects downwardly as shown in FIG. **11**, so that string passageway **242** aligns with the string holes **227** in the base plate **220**.

The reinforcement rib **245** is bent about the line forming the uncut edge of the reinforcement rib. The rib **245** is then attached to the lower surface of the base plate. In the present instance, the rib **245** is connected to the base plate **220** by a fastener, such as a screw **246**, extending through the base plate and into an internally threaded portion in the rib.

In this way, the tremolo base plate **220** is integrally formed with the spring blade **240** from a single piece of material, so that a single unitary component connects the tremolo to the spring that biases the tremolo against the tension in the instrument strings.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

I claim:

**1**. A tuning apparatus for a stringed musical instrument comprising:
- a body and
- a neck extending outwardly from said body,
- a plurality of strings extending from the body to the neck,
- a first critical point for each of said strings on the neck,
- a second critical point for each of the strings on the body,
- the apparatus further comprising:

a base comprising a forward end and a rearward end and upper portion and a lower portion, comprising:
- a bridge element connected to the base, the bridge element located closer to the forward end forming a second critical point; and
- a first portion connected to the base and located in the rearward end forming an alternate string anchoring point closer to the lower portion than the second critical point, and
- wherein the lower portion being attached to the upper portion and the lower portion comprises:
  - a second portion that is transverse to the alternate string anchoring point;
  - and a first string anchoring point.

**2**. The apparatus of claim **1**, wherein the apparatus further comprises:
- a fulcrum tremolo.

**3**. The apparatus of claim **1**, wherein the upper portion further comprises:
- a string opening located between the first anchoring point and the second critical point, and

wherein the second portion further comprises:
- a member with a string passageway connected to the second anchoring point having an axis, the axis being aligned to the string opening in the upper portion.

**4**. The apparatus of claim **3**, wherein the apparatus further comprises:
- a fulcrum tremolo.

**5**. An apparatus comprising:
- a bridge element and
- a tailpiece element connected to the bridge element, the tailpiece comprising:
  - a first portion having a rearward surface having a string anchoring point comprising a recess formed to receive a string anchor therein and
  - a second portion that is transverse to the first portion comprising:
  - a first end that connects the second portion to the first portion;
  - a second end, the second end having an alternate string anchoring point comprising a recess formed to receive a string anchor and an elongated passageway that extends through the second portion from the first end to the second end, along a longitudinal axis of the second portion, forming at least one opening on each end.

**6**. An apparatus comprising:
- a body;

a fulcrum tremolo;

a biasing element comprising a first end connected to the fulcrum tremolo and a second end connected to the body; and

at least one biasing element holder; and

a singular apparatus directly connected to the biasing element the singular apparatus comprising:

a thumbwheel portion operable to position the at least one biasing element holder,

wherein rotation of the thumbwheel portion alters the bias applied by the biasing element.

7. The apparatus of claim 6, wherein the singular apparatus further comprises:

a U-shaped spring.

8. An apparatus for a stringed musical instrument comprising:

a body; and

a fulcrum tremolo,

the apparatus comprising:

a biasing element, the biasing element comprising at least one spring comprising a first end and a second end, the first end and the second end positioned opposite from each other on the at least one spring, the at least one spring positioned between the fulcrum tremolo and the body;

a spring holder connected to the biasing element;

a singular apparatus in direct contact with the at least one spring, the singular apparatus comprising a thumbwheel and

a threaded elongated portion, the threaded elongated portion threadedly connected to the singular apparatus and the threaded elongated portion threadedly connected to the singular apparatus,

wherein rotation of the thumbwheel alters the bias applied by the at least one spring.

9. The apparatus of cliam 8, wherein the singular apparatus further comprises:

a secondary spring holder being threadedly engaged with the threaded elongated portion, and

wherein the fulcrum tremolo being positioned between the thumbwheel and the secondary spring holder.

10. The apparatus of cliam 8, wherein the spring holder being positioned between the thumbwheel and the biasing element.

11. The apparatus of claim 10, further comprising a secondary spring holder connected to the biasing element,

wherein the thumbwheel further comprises a second elongated threaded portion, wherein the fulcrum tremolo further comprises a threaded opening, and

wherein the thumbwheel is positioned between the secondary spring holder and the threaded opening.

12. A fulcrum tremolo with a forward end and a rearward end, the fulcrum tremolo comprising:

a base plate comprising a string hole,

a spring holder that is transverse to the base plate comprising:

a tailpiece,

the tailpiece comprising a string anchoring point; and

a string passageway having an axis wherein a longitudinal axis of the string passageway aligns with the string hole;

an intonation module attached to the spring holder comprising:

a bridge element connected to the base, the bridge element located closer to the forward end than the rearward end and



wherein the rearward portion forms an alternate tailpiece, the alternate tailpiece comprising an alternate string anchoring point; and

wherein the alternate string anchoring point is located a distance from the second critical point so that a string is rendered essentially inextensible between the alternate string anchoring point and the second critical point.

13. The fulcrum tremolo of claim 12, wherein the intonation module further comprises:

a macro tuner.

14. A tremolo for a stringed musical instrument comprising: at least one bridge element; and

a unitary component that is a single piece of bent material comprising:

a base plate being approximately planar, comprising:

a forward edge, a portion of the forward edge being a pivot and forming a pivot axis, and

an end opposite of the forward edge;

the opposite end of the forward edge of the base plate comprising:

a bend in the unitary component;

a transverse portion comprising:

at least one spring socket to receive an end of at least one biasing element; and

wherein the bend transitions the base plate to the transverse portion, and

wherein the bend and the transverse portion are approximately parallel to the pivot axis, and

wherein the unitary component is connected to the at least one bridge element.

15. The tremolo of claim 14, wherein the transverse portion further comprises:

at least one string socket.

16. A fulcrum tremolo for a stringed musical instrument comprising:

a unitary component that is a single piece of bent material comprising:

a base plate being approximately planar, comprising:

a forward edge, a portion of the forward edge being a pivot and forming a pivot axis, and

an end opposite of the forward edge;

a first bend in the unitary component at an opposite end of the forward

edge of the base plate;

and a transverse portion comprising:

at least one spring socket to receive an end of at least one biasing element,

wherein the first bend transitions the base plate to the transverse portion,

and

wherein the first bend and the transverse portion are approximately parallel to the pivot axis,

at least one bridge element connected to the unitary component.

17. The fulcrum tremolo of claim 16, wherein the first bend further comprises:

a reinforcement.

18. The fulcrum tremolo of claim 16, wherein the transverse portion further comprises:

at least one string socket to receive an end of a string.

19. The fulcrum tremolo of claim 18, wherein the base plate further comprises at least one string hole, and

wherein the transverse portion further comprises:

an upper portion;

a lower portion comprising at least one string passageway, each of the at least one string passageway is aligned with at least one of the least one string hole in the base plate; and

at least one second bend that transitions from the upper portion to the lower portion,

wherein the lower portion is approximately parallel to the pivot axis.

**20**. The fulcrum tremolo of claim **18**, wherein the base plate further comprises:

at least one tier for displacing the at least one bridge element from the base plate.

**21**. The fulcrum tremolo of claim **16**, wherein the transverse portion further comprises:

the at least one string socket.

**22**. The fulcrum tremolo of claim **16**, wherein the pivot further comprises: a pivot having a knife edge.

**23**. The fulcrum tremolo of claim **16**, wherein the pivot further comprises: a pivot having a beveled edge.

**24**. The fulcrum tremolo of claim **16**, wherein the pivot further comprises:

at least a portion of a ball bearing surface.

**25**. The fulcrum tremolo of claim **16**, wherein the pivot further comprises: at least a portion of a ball bearing surface; and

at least a portion of a shaft.

**26**. A fulcrum tremolo for a stringed musical instrument comprising:

at least one bridge element; and

a unitary component that is a single piece of bent plate material having a substantial uniform thickness comprising:

a base plate being approximately planar, comprising:

a pivot forming a pivot axis;

at least one bend in the base plate;

at least one additional portion formed to receive at least a portion of at least one bearing assembly,

wherein the at least one bend and the at least one additional portion have an axis approximately parallel to the pivot axis, and

wherein the unitary component is connected to the at least one bridge element.

**27**. A fulcrum tremolo for a stringed musical instrument comprising

at least one bridge element; and

a base plate being approximately planar, comprising:

a forward edge, and;

at least one additional portion formed to receive at least a portion of at least one bearing assembly;

the at least one bearing assembly, comprising:

at least a portion of a shaft, at least one housing,

at least a portion of a ball bearing surface, and at least one annular flange

wherein the at least one annular flange spaces the at least a portion of at least one bearing assembly way from the base plate.

**28**. A bridge-tailpiece for a stringed musical instrument comprising:

a fulcrum tremolo, the fulcrum tremolo further comprising:

an element to receive at least one musical instrument string, the element comprising:

a first string anchoring point for each string; and

an alternate string anchoring point for each string; and

an intonation module with a forward portion and a rearward portion;

the intonation module comprising:



a base;

a bridge element connected to the base, the bridge element located closer to the forward end forming a second critical point; and

wherein the rearward portion forms a string anchoring point closer to the base than the second critical point; and

wherein the string anchoring point is located a critical distance from the second critical point operable to render a string as approximately inextensible between the anchoring point and the second critical point;

and

a biasing element comprising a first end connected to the fulcrum tremolo and a second end connected to the body; and

at least one biasing element holder; and

a singular apparatus connected to the fulcrum tremolo, the singular apparatus comprising:

a thumbwheel portion operable to position the at least one biasing element holder,

wherein rotation of the thumbwheel portion adjusts the equilibrium point between the tension of the strings and the tension of the biasing element to adjust initial position;

and

an unitary component that is a single piece of bent material comprising:

a base plate being approximately planar, comprising:

a forward edge, a portion of the forward edge being a pivot and forming a pivot axis, and

an end opposite of the forward edge;

the opposite end of the forward edge of the base plate comprising:

a first bend in the unitary component;

and a transverse portion comprising:

at least one spring socket to receive an end of at least one biasing element,

wherein the first bend transitions the base plate to the transverse portion,

and

wherein the first bend and the transverse portion are approximately parallel to the pivot axis;

the unitary component further comprising:

at least one additional portion formed to receive at least a portion of at least one bearing assembly,

wherein the at least one bend and the at least one additional portion have an axis approximately parallel to the pivot axis, and

wherein the unitary component is connected to the at least one bridge element.

**29**. A fulcrum tremolo for a stringed musical instrument comprising a body and a neck, a plurality of strings extending from the body to the neck, a nut for supporting the strings on the neck forming a first critical point for each string wherein the fulcrum tremolo comprises a macro tuner:

the macrotuner having a forward end closer the nut and a rearward end further the nut, the macro tuner comprising:

base;

a bridge element connected to the base located closer the forward end forming a second critical point;

an elongated portion slideably connected to the base;

a string holder element, the string holder further comprises a tailpiece, and

an adjustment screw connected to the base operable to position the elongated portion;

the elongated member, the adjustment screw and the string holder located on the opposite side of the second critical point from the first critical point,

wherein threading the adjustment screw is operable to position the string holder element to change tension of strings.

30. The macro tuner of claim 29, wherein the base further comprises a restricted portion,

the elongated member further comprises:

a clamping portion closer to the second critical point;

a sting passageway; and

an annular flange, and

wherein the annular flange is in varying contact with the restricted portion;

wherein threading the adjustment screw to tension a string is operable to clamp the string between the second critical point and the tailpiece.

31. A macro tuner having a front end and a rearward end, the macro tuner comprising:



a bridge element located closer the front end forming an intonation point;

an elongated member slideably connected to the macro tuner, the elongated member located on the opposite side of the bridge element from the front end,

an adjustment screw connected to the macro tuner operable to position the elongated member; the adjustment screw located on the opposite side of the bridge element from the front end,

a string holder element connected to the elongated member located on the opposite side of the bridge element from the front end, the strong holder element comprising a tailpiece comprising a string anchoring point,

wherein threading the adjustment screw is operable to position the string holder element to tension a string, and

wherein the macro tuner is located on an apparatus consisting of a fulcrum tremolo.

* * * * *

JS 44 (Rev. 12/07)

# CIVIL COVER SHEET

FILED

The JS 44 civil cover sheet and the information contained herein neither replace nor supplement the filing and service of pleadings or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. (SEE INSTRUCTIONS ON THE REVERSE OF THE FORM.)

2010 MAR 19 PM 1:20

## I. (a) PLAINTIFFS

Geoffrey L. McCabe, Individual

(b) County of Residence of First Listed Plaintiff Los Angeles, CA
(EXCEPT IN U.S. PLAINTIFF CASES)

(c) Attorney's (Firm Name, Address, and Telephone Number)
San Diego IP Law Group LLP, 12526 High Bluff Drive, Suite 300
San Diego, CA 92130 - (858) 792-3446

## DEFENDANTS

Floyd Rose Guitars; Floyd Rose Marketing, Inc.; Floyd D. Rose; Davitt & Hanser Music Co.; Ping Well Industrial Co.

County of Residence of First Listed Defendant King, WA
(IN U.S. PLAINTIFF CASES ONLY)
NOTE: IN LAND CONDEMNATION CASES, USE THE LOCATION OF THE LAND INVOLVED.

BY DEPUTY

Attorneys (If Known)

'10 CV 0581 W JMA

## II. BASIS OF JURISDICTION (Place an "X" in One Box Only)

- ☐ 1 U.S. Government Plaintiff
- ☒ 3 Federal Question (U.S. Government Not a Party)
- ☐ 2 U.S. Government Defendant
- ☐ 4 Diversity (Indicate Citizenship of Parties in Item III)

## III. CITIZENSHIP OF PRINCIPAL PARTIES (Place an "X" in One Box for Plaintiff and One Box for Defendant) (For Diversity Cases Only)

| | PTF | DEF | | PTF | DEF |
|---|---|---|---|---|---|
| Citizen of This State | ☐ 1 | ☐ 1 | Incorporated *or* Principal Place of Business In This State | ☐ 4 | ☐ 4 |
| Citizen of Another State | ☐ 2 | ☐ 2 | Incorporated *and* Principal Place of Business In Another State | ☐ 5 | ☐ 5 |
| Citizen or Subject of a Foreign Country | ☐ 3 | ☐ 3 | Foreign Nation | ☐ 6 | ☐ 6 |

## IV. NATURE OF SUIT (Place an "X" in One Box Only)

- ☐ 110 Insurance
- ☐ 120 Marine
- ☐ 130 Miller Act
- ☐ 140 Negotiable Instrument
- ☐ 150 Recovery of Overpayment & Enforcement of Judgment
- ☐ 151 Medicare Act
- ☐ 152 Recovery of Defaulted Student Loans (Excl. Veterans)
- ☐ 153 Recovery of Overpayment of Veteran's Benefits
- ☐ 160 Stockholders' Suits
- ☐ 190 Other Contract
- ☐ 195 Contract Product Liability
- ☐ 196 Franchise
- ☐ 210 Land Condemnation
- ☐ 220 Foreclosure
- ☐ 230 Rent Lease & Ejectment
- ☐ 240 Torts to Land
- ☐ 245 Tort Product Liability
- ☐ 290 All Other Real Property

PERSONAL INJURY
- ☐ 310 Airplane
- ☐ 315 Airplane Product Liability
- ☐ 320 Assault, Libel & Slander
- ☐ 330 Federal Employers' Liability
- ☐ 340 Marine
- ☐ 345 Marine Product Liability
- ☐ 350 Motor Vehicle
- ☐ 355 Motor Vehicle Product Liability
- ☐ 360 Other Personal Injury
- ☐ 441 Voting
- ☐ 442 Employment
- ☐ 443 Housing/ Accommodations
- ☐ 444 Welfare
- ☐ 445 Amer. w/Disabilities - Employment
- ☐ 446 Amer. w/Disabilities - Other
- ☐ 440 Other Civil Rights

PERSONAL INJURY
- ☐ 362 Personal Injury - Med. Malpractice
- ☐ 365 Personal Injury - Product Liability
- ☐ 368 Asbestos Personal Injury Product Liability

PERSONAL PROPERTY
- ☐ 370 Other Fraud
- ☐ 371 Truth in Lending
- ☐ 380 Other Personal Property Damage
- ☐ 385 Property Damage Product Liability
- ☐ 510 Motions to Vacate Sentence

Habeas Corpus:
- ☐ 530 General
- ☐ 535 Death Penalty
- ☐ 540 Mandamus & Other
- ☐ 550 Civil Rights
- ☐ 555 Prison Condition

- ☐ 610 Agriculture
- ☐ 620 Other Food & Drug
- ☐ 625 Drug Related Seizure of Property 21 USC 881
- ☐ 630 Liquor Laws
- ☐ 640 R.R. & Truck
- ☐ 650 Airline Regs.
- ☐ 660 Occupational Safety/Health
- ☐ 690 Other
- ☐ 710 Fair Labor Standards Act
- ☐ 720 Labor/Mgmt. Relations
- ☐ 730 Labor/Mgmt.Reporting & Disclosure Act
- ☐ 740 Railway Labor Act
- ☐ 790 Other Labor Litigation
- ☐ 791 Empl. Ret. Inc. Security Act
- ☐ 462 Naturalization Application
- ☐ 463 Habeas Corpus - Alien Detainee
- ☐ 465 Other Immigration Actions

- ☐ 422 Appeal 28 USC 158
- ☐ 423 Withdrawal 28 USC 157
- ☐ 820 Copyrights
- ☒ 830 Patent
- ☐ 840 Trademark
- ☐ 861 HIA (1395ff)
- ☐ 862 Black Lung (923)
- ☐ 863 DIWC/DIWW (405(g))
- ☐ 864 SSID Title XVI
- ☐ 865 RSI (405(g))
- ☐ 870 Taxes (U.S. Plaintiff or Defendant)
- ☐ 871 IRS—Third Party 26 USC 7609

- ☐ 400 State Reapportionment
- ☐ 410 Antitrust
- ☐ 430 Banks and Banking
- ☐ 450 Commerce
- ☐ 460 Deportation
- ☐ 470 Racketeer Influenced and Corrupt Organizations
- ☐ 480 Consumer Credit
- ☐ 490 Cable/Sat TV
- ☐ 810 Selective Service
- ☐ 850 Securities/Commodities/ Exchange
- ☐ 875 Customer Challenge 12 USC 3410
- ☐ 890 Other Statutory Actions
- ☐ 891 Agricultural Acts
- ☐ 892 Economic Stabilization Act
- ☐ 893 Environmental Matters
- ☐ 894 Energy Allocation Act
- ☐ 895 Freedom of Information Act
- ☐ 900Appeal of Fee Determination Under Equal Access to Justice
- ☐ 950 Constitutionality of State Statutes

VIA FAX

## V. ORIGIN (Place an "X" in One Box Only)

☒ 1 Original Proceeding ☐ 2 Removed from State Court ☐ 3 Remanded from Appellate Court ☐ 4 Reinstated or Reopened ☐ 5 Transferred from another district (specify) ☐ 6 Multidistrict Litigation ☐ 7 Appeal to District Judge from Magistrate Judgment

## VI. CAUSE OF ACTION

Cite the U.S. Civil Statute under which you are filing (Do not cite jurisdictional statutes unless diversity):
35 U.S.C. 271; 35 U.S.C. 292

Brief description of cause:
Patent Infringement; False Marking; and Unfair Competition

## VII. REQUESTED IN COMPLAINT:

☐ CHECK IF THIS IS A CLASS ACTION UNDER F.R.C.P. 23

DEMAND $

CHECK YES only if demanded in complaint:
JURY DEMAND: ☑ Yes ☐ No

## VIII. RELATED CASE(S) IF ANY

(See instructions): JUDGE DOCKET NUMBER

DATE 3/19/10

SIGNATURE OF ATTORNEY OF RECORD

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RECEIPT # 11322 AMOUNT $350- APPLYING IFP JUDGE MAG. JUDGE

03-19-10

eP

Court Name: USDC California Southern
Division: 3
Receipt Number: CAS011322
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Transaction Date: 03/19/2010
Payer Name: KNOX ATTORNEY SERVICES

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CIVIL FILING FEE
For: McCABE V FLOYD ROSE GUITARS
Case/Party: D-CAS-3-10-CV-000581-001
Amount: $350.00

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CHECK
Check/Money Order Num: 4714
Amt Tendered: $350.00

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Total Due: $350.00
Total Tendered: $350.00
Change Amt: $0.00

There will be a fee of $45.00
charged for any returned check.